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A carefully designed system of blow-offs is in use in connection with the Providence water-works and was recently described in the Providence "Journal" by Mr. Edmund B. Weston, M. Am. Soc. C. E., engineer in charge of the works. About 30 6-in. and 8-in. blow-offs, discharging into the river or sewers, are located upon the 30 and 24-in. mains, from 700 to 3,500 ft. apart. When it is desired to clear a length of pipe, it is cut out by means of stop valves and water is admitted through some one or more of the smaller connecting mains, giving a velocity of from 2 to 4 ft. per second in the blow-off pipe. For dead ends on small mains 1-in. pipes are provided, unless a hydrant is available. Dead ends are blown off upon complaint of dirty water. It is said that about 40,000,000 gallons of water were used last June in blowing off the low service system.

The Ohio Road Commission has filed its report with Governor McKinley and estimates that at an average cost of $5,000 per mile it would require $400,000,000 to improve all the roads in that state, and the commissioners further estimate that the average cost of transportation by horses or wagons over country roads is in any event about 25 cts. per ton mile, as contrasted with about ½ ct. per ton mile for transportation by steam over railways. Arguing from this prohibitive cost of road construction and from the waste in any transportation by horse power over even improved roads, the commission favors the laying of steel rails on highways and the substitution of electric or other inanimate power for the horse for the transportation of both freight and passengers. In short, the two commissioners, Messrs. Martin Dodge and D. W. Sprague, do not recommend the improvement of the highways at the expense of the state, but suggest instead the extension, at local expense, of the suburban electric roads already doing good service in the state. The commission believes this to be more just to the people in general and more economical in the end, especially in the relative cost of transportation per ton-mile.

Over two miles of cedar block paving on a slag foundation was put down at Lake Forest, Ill., a suburb of Chicago, during the past season. The work cost about $45,000, and was done by the Ross Sapless Paving Block Co., of Saginaw, Mich., with Alexander, Hill & Enricht, Chamber of Commerce Building, Chicago, as engineers. The slag was spread 7 ins. in depth and covered with gravel sufficient to fill all interstices and leave ½ in. cover over all. After a thorough rolling a cushion of from 1 to 2 ins. of sand was spread over the slag, and upon this 6 ins. of sapless cedar blocks were placed. Clean lake shore gravel was then swept over the surface, entirely filling all spaces between the blocks and leaving the surface free from stone. The paving was then thoroughly rolled with a six-ton Pope reversible roller, which left the surface as smooth as when laid upon a plank foundation. The work was then completed as in ordinary cedar paving.

The Eads isthmian ship railway is again before the House Committee of Congress on Interstate and Foreign Commerce. It is understood that this committee is considering the creation of a joint commtitee to investigate and report upon the practicability and merits of the Nicaragua Canal. Mr. John H. Rice, the president of the Atlantic and Pacific Ship Railway Co., and Mr. James Andrews, managing director of the same company, ask that this same committee also investigate the practicability of the ship railway projected across Mexico between the oceans.

Harvard College, according to the catalogue for the academic year 1893-94, has 3,156 students and 322 teachers in its several departments. The college proper has 1,656 students; scientific school, 280; gradate school, 252; law school, 353; medical school, 446. There are 28 more teachers and 190 more students than in 1892-93. The library contains 431,650 volumes, a gain of over 22,000 in the year.

The most serious railway accident of the week was the breaking down of a trestle under a train on the San Antonio & Aransas Pass Ry., near Winchester, Tex., Dec. 19. The rear truck of the tender jumped the track on the approach and caused the collapse of the structure, which was about 25 ft. long and 15 ft. high. The engine and rear car remained on the track on opposite sides of the gap, but the tender, baggage car and smoking car went down. One man was killed and six were injured. The temporary trestle, which replaced the Chester Bridge in the Boston & Albany R. R., which fell Aug. 31, was carried away by ice, but an accident was fortunately averted.

A trestle on the Duluth, South Shore & Atlantic Ry., near Croll, Wis., gave way under a freight train Dec. 22.——A private bridge, at Boone, Ia., belonging to Birmingham & Keating, and crossing the Des Moines River, gave way under a train of loaded coal cars Dec. 24. One man was killed.——A highway bridge over Bennett's Creek, near Cannisteo, N. Y., gave way under a team Dec. 18 and the driver was killed.

The concrete base under the wood pavements of some of the London streets, reports Mr. Foulger, Chief Engineer of the London Gas Co., has formed an arch across the street sufficiently strong to support the entire traffic. On Oxford St., in some parts, the loose earth beneath has settled so much that a man can crawl under the concrete. In addition to the danger of a sudden collapse, this space is found to be filled with a mixture of gas escaping from the street mains, and should this mixture attain explosive proportions blowing up of a section of the street is possible.

The bill for the New York & New Jersey Bridge across the Hudson River has passed the Senate and House of Representatives, and is now ready for the president's signature.

The Master Mechanics' Association has a committee at work investigating special oiling devices for locomotives making long runs without stopping. Mr. J. Davis Barnett, Grand Trunk Ry., Stratford, Ont., is chairman. Another committee, headed by Mr. A. E. Mitchell, of the New York, Lake Erie & Western, is investigating the treatment of ties and has issued a circular asking answers to 18 questions on this subject.

An important improvement in planimeters has been devised by Prof. D. S. Jacobus, of Stevens Institute. It consists in the substitution for the ordinary tracing point of a glass plate having two hair lines cut on its under side at right angles. In tracing a diagram the point of intersection of these lines is kept on the line to be traced. The ordinary point has a tendency to make a slight groove in the paper, so that on a second tracing the point tends to follow in the groove left by the first. Again, where repeated tracings have to be made the point tends to obliterate the line. The improved form of tracer is open to no such objection, and it can be used in the evening, while the ordinary planimeter cannot on account of the shadow cast by the tracing point.

Important works are in progress at Libau, the most southern harbor which Russia possesses in the Baltic, and which is free from ice some weeks before the other ports. The concrete blocks used for the construction of the breakwaters and piers are 7, 8, 10 and 12 ft. long and 3 to 6 ft. thick. From the outer or temporary harbor a canal is in course of construction, 2½ miles long, with a breadth of 510 ft. at the surface and 240 ft. at the bottom, and some parts will be wider in order that ships may be able to pass with ease. The ground is at first excavated by hand and then two dredges cut to a depth of 14 ft., and these are followed by about six sand pump dredges. At the end of this canal will be two dock basins 900 × 2,400 ft. and 600 × 1,800 ft., with drydocks, workshops, etc., for warships. Mr. Edelheim is the resident engineer.

Electric percussion rock drills and reciprocating tools for cutting and carving stone were exhibited at the World's Columbian Exposition by the MacKay Electric Reciprocating Tool Co., of Boston, Mass. They are operated by electromagnets or solenoids connected in series to a continuous source of electricity, and so arranged that when the armature or drill stock moves down it brings a sliding commutator in contact with a set of commutator plates, thus making a path of lower resistance through the upper magnet and short circuiting the lower magnet. The upper magnet then draws the plunger and drill up, till the sliding commutator makes contact with another set of commutator plates, short circuiting the upper magnet and energizing the lower one. The circuit is never broken, but only changed by the commutator, and the machines can be worked from an incandescent light circuit without interfering with the lights. The large mining drills absorb about 2 HP. and make 400 strokes per minute. Smaller machines, held in the hand, are made for wood carving, sculpture, etc.

The total number of merchant steamers in the world of over 100 tons net tonnage is 10,629, representing 15,134,436 gross tons, or 9,674,814 net tons. The total number of sailing vessels over 50 tons is 29,756, with 9,829,063 net tons. So says the last report of the French "Bureau Veritas," and the same authority states that out of the above number of steamers 5,694 sail under the English flag, or more than half of the world's steam merchant fleet.

A testing laboratory in connection with the engineering department of Peoria, Ill., has been established by Mr. Jacob A. Harman, City Engineer, and an appropriation has been made for a 100,000-lb. Riehle machine, a 7,000-lb. cement machine and a brick testing machine. This is an example which might well be followed by many other cities.

Screw spikes are used by the Pennsylvania R. R. for fastening the angle bars of its 100-lb. steel rails to the ties, as noted in our issue of Sept. 7, 1893, and we are indebted to Mr. Joseph W. Richardson, Engineer of Maintenance of Way, for a blueprint showing the arrangement. The spikes are ⅝ in. diameter and 6½ ins. long under the head, which is ⅝ in. thick. They pass through holes in the angle bars, the shank of the spike touching the edge of the rail, and a cast washer between the angle bar and spike head giving a horizontal bearing to the head. The rails are laid with broken suspended joints, spliced by 34-in. angle bars and six bolts. We have already referred to the necessity of introducing a more efficient fastening than the ordinary spike for heavy rails on track carrying heavy traffic (Eng. News, July 13, 1893), and we should like to see the Pennsylvania R. R., which is so well able financially to introduce improvements, use its screw spikes for standard rail fastenings. A screw spike fastening in which the spikes are driven in an inclined direction and bear on steel clamps, has been designed by Colonel Katte, Chief Engineer of the New York Central R. R., as also noted in our issue of Sept. 7.

A boring now 6,568 ft. deep is being made at Paruschowitz, in the district of Ribnik, West Silicia. The upper diameter of the hole is 11.8 ins. and the bottom is now 2¾ ins. in diameter. Mannesmann tubes were used, provided with a diamond cutting edge, and a special device was employed for cutting off the core at the bottom. The length of the tubes is not stated; but when a boring with one length had been completed a tube was attached having an outside diameter equal to the inside of the upper one, and provided in turn with a diamond drill. After carefully ascertaining the temperatures at various depths in the present hole, it is proposed to continue it, if possible, to a depth of 8,200 ft.

An international agreement to remove or destroy derelicts and other obstructions to navigation on the high seas, as recommended by the last Congress, is a proposition earnestly approved of by all interested in shipping, and the result of the conference soon to be called can only be favorable. Mr. O'Brien, chief of the navigation bureau of the U. S. Treasury Department, is mainly responsible for the passage of the measure, and he wants the execution of this work transferred to his department. Heretofore the Hydrographic Department has had it in charge, though beyond a coast zone no nation has made a special business of destroying wrecks on the high seas. It is believed that this can be done effectually by a vessel especially constructed and equipped for this service.

TRANSVERSE STRENGTH OF BRICK MASONRY.

Very little attention has ever been given by engineers in general to the transverse strength of brick masonry, notwithstanding its frequent use in positions where this strength is called into action. It is generally admitted, of course, that brick masonry has considerable strength to resist pressure as a beam, and this property is tacitly allowed for in constructing openings for doors and windows, but the record of definite experiments made to determine the limits of this transverse strength are very meagre. The following abstract of a series of experiments on the transverse strength of brick masonry made by Messrs. M. A. Earl and A. B. Loomis, of the engineering department of the University of Illinois, and published in a recent number of the "Technograph," a student's publication, is, therefore, of considerable interest.

In these experiments eight beams and two piers were broken. The beams were broken as simple beams with a concentrated load at the center, and the piers were first broken as cantilever beams and afterward as simple beams. The conditions and results of the several tests were as follows:

Beam No. 1 was built of two thicknesses of stretchers like an ordinary double wall, with the third course from the bottom headers. There was also a bond at the ends. Its depth was 14.7 ins. and the distance between supports 43.75 ins. Its age when broken was 28 days. The beam failed at the center, about as much from lack of cohesion in the mortar as from mortar separating from the brick. This statement will apply to all the beams. One brick was broken by tension. Since the weight of the beam, 350 lbs., acts as a uniform load, its effect is the same as 175 lbs. at the center. Hence the breaking load = 1,652 + 175 = 1,827 lbs. The modulus of rupture, therefore,

$$= \frac{6\,M}{d^2\,b} = \frac{6 \times 1827 \times 43.5}{4 \times 7.75 \times 217.56} = 70.7.$$

Pier No. 1 was pulled over as a cantilever beam. Age, 28 days. Failed by mortar separating from brick. Weight of pier, 295 lbs. Force to break, 205 lbs. applied 42.5 ins. from joint of rupture. Maximum tension per sq. in.

$$= \frac{Ml}{2I} - \frac{W}{s} = \frac{205 \times 42.5 \times 11\frac{1}{2}}{2 \times \frac{1}{12} \times 7\frac{1}{2}\,(11\frac{1}{2})^3} - \frac{295}{7\frac{1}{2} \times 11\frac{1}{2}} = 49.3$$

Beam No. 2 consisted of pier No. 1 broken as a simple beam. Length between supports, 43 ins.; depth, 7½ ins.; width, 11½ ins. Weight, 295 lbs. Load to break: concentrated, 160 lbs.; weight of beam considered at center, 148 lbs.

$$S = \frac{6\,M}{b\,d^2} = \frac{6 \times 308 \times 43}{4 \times 11\frac{1}{2} \times (7\frac{1}{2})^2} = 30.7 \text{ lbs. per sq. in.}$$

In this case, and also in the pier, the unit stress is necessarily small, since there is no interlocking action of the brick as in an ordinary beam.

Beam No. 3 was built essentially the same as No. 1. Age, 56 days. Length, 4 ft.; depth, 4¾ in.; width, 7¾ ins.; distance between supports, 43 ins. Weight, 350 lbs. Concentrated load, 3,273 lbs. The beam did not fail, thus showing a strength of at least 117.2 lbs. per sq. in.

It was then turned on the flat side and broken with a concentrated load of 1,507 lbs., or 122.4 lbs. per sq. in.

Beam No. 4.—Age, 49 days; depth and width consisted of the same number of courses as No. 1; depth, 15 in.; distance between centers, 122 ins.; width, 7¾ ins.; weight, 1,000 lbs. Five bricks broke when the beam failed. When this beam was broken deflections were taken at the center by means of a level and rod. These are given in the following table:

Deflection, in.	Differences.	Weights applied.
0.00	0.00	0.00
0.05	0.05	....
0.06	0.01	+ 200 lbs.
0.07	0.01	+ 400 "
0.11	0.04	+ 600 "
0.17	0.06	+ 800 "
0.23	0.06	+ 1,000 "
	Beam broke..........	+ 1,224 "

At the vertical joints the mortar separated from brick; at the horizontal joints the mortar failed in cohesion. Strain, 181 lbs. per sq. in.

Beam No. 5.—Depth, 15 in.; width, 7¾ ins.; distance between supports, 55 ins.; weight, 500 lbs.; age, 61 days; breaking load applied at center, 1,678 lbs. Strain, 91.2 lbs. per sq. in.

Beam No. 6.—Width and depth the same as No. 5; distance between supports, 55 ins.; age, 62 days; breaking load, 2,070 lbs.; weight of beam, 500 lbs. Strain, 115.5 lbs. per sq. in.

Beam No. 7.—Age, 62 days; distance between supports, 44 ins.; depth, 7¼ ins.; width, 3½ ins.; center load, 378 lbs.; weight of beam, 80 lbs.; strain, 153.8 lbs. per sq. in. The beam was not broken.

Beam No. 8.—Two courses high and two courses wide; depth, 4½ ins.; width, 7½ ins.; distance between supports, 45 ins.; weight of beam, 125 lbs.; breaking load, 200 lbs.; age, 62 days; strain, 112.7 lbs. per sq. in.

Beam No. 9.—Lower section as No. 2; built as pier; distance between supports, 37 ins.; width, 7½ ins.; depth, 11½ ins.; age, 62 days; weight of beam, 270 lbs.; center load, 970 lbs.; strain, 54.3 lbs. per sq. in.

Beam No. 10.—Age, 35 days; distance between supports, 6 ft.; depth, 14 ins.; width, 8 ins.; center load, 1,000 lbs.; weight of beam, 670 lbs.; strain, 99 lbs. per sq. in.

A summary of the results of the tests giving the modulus of rupture for the several beams is given in the following table:

No of beam.	Age, days.	Strength of mortar at that age, in lbs. per sq. in.	Modulus of rupture of beam in lbs. per sq. in.	Remarks.
3	56	50	117.2 to 122.4	Broken sidewise
4	49	48	181	Mortar 1 to 2 by vol.
5	61	52	91.2	"
6	62	52	115.5	"
7	62	52	153.8	"
8	62	52	112.7	"
10	35	45	99.0	"
9	62	52	54.3	"
2	28	40	30.7	Mortar 1 to 2 by wgt.
1	28	40	71.1	"
Pier	28	40	49.3	"

The table shows, roughly, that the beams built as regular masonry have a modulus of rupture of about twice the tensile strength of the mortar used. With the best construction it may be even three times the tensile strength of the mortar, as shown by beams Nos. 4 and 7. When built as piers, with no interlocking action, the modulus of rapture is about the same as the tensile strength of the mortar used. The experiments on deflections with beam No. 4, while not enough to draw any certain conclusion from, would seem to show that brick masonry is elastic, and that up to a certain point the deformation is proportional to the stress applied. The result of experiments in the past, while showing a certain transverse strength, have not been definite or uniform enough to furnish reliable conclusions. While the nature of this subject does not permit of its being carried in an experimental way as far as might be desired, without considerable expense, it is suggested that much can yet be done toward finding the strength actually obtained in brick buildings. The tearing down or failure of such buildings affords an excellent opportunity for this, and it is to be hoped that experiment and observation will be turned in this direction.

RECONSTRUCTION OF A DEFECTIVE PIVOT PIER.

The work of removing and rebuilding the defective pivot pier of the Coosa River bridge on the Anniston & Cincinnati R. R. was described and illustrated in our issue of April 13, 1893, and we give below an abstract of a paper describing a similar work on the St. Louis, Arkansas & Texas R. R. This paper is by Mr. Howard G. Kelley, and was read Dec. 6 before the American Society of Civil Engineers. The following abstract is taken from the Society's bulletin:

The St. Louis, Arkansas & Texas R. R. draw span, with four panels of trestle approach, crossing the Ouachita River, at Camden, Ark., was wrecked on Sept. 13, 1890, and a 60-ton mogul engine and nine loaded freight cars fell into the river with the collapsed structure. The span destroyed was a combination Howe truss draw of 290 ft. total span, with curved iron top chord and iron bottom chord, erected in 1883, the road at that time being narrow gage. The pivot pier consisted of a cluster of cylinders; the central cylinder, 6 ft. in diameter, surrounded by six cylinders each 4 ft. in diameter, all braced together. The rest piers were ordinary framed bridge seats on foundation piling. The bed of the river was 70 ft. below grade in its deepest portion. The bottom consisted of sand with strata of sandy clay 4 to 6 ins. thick at intervals of about 10 ft. in depth.

In making repairs the broken span was pulled out of the way downstream, the engine and cars rolled out of the way and a temporary trestle was erected. Pine piles 70 to 85 ft. long were obtained at a few miles' distance, and by the night following the accident a track pile driver was started upon the south end, and on the following afternoon a second machine started on the north end. Five piles were driven to each bent and braced with 3 × 10 in. plank; the bents were spaced at 14 ft. centers, cribbing being used over the pivot pier. By noon of Sept. 19 the trestle was completed and trains crossed the bridge. Application was made to the War Department for the privilege of reducing the length of span, but this was denied; and in November a contract was let to the Detroit Bridge & Iron Works for a new bridge 290 ft. between centers of end pins.

An examination of the pivot pier showed extremely poor concrete, much of it being uncemented. The cylinders penetrated 14 to 16 ft. into the bed of the river, and, as no piles had been driven in the bottom of them during the founding, they were, after much consideration, condemned and the cylinder cluster was removed and replaced by a cylindrical pier. The Ouachita is a turbulent river, showing rises of 15 ft. in one night; but near Camden it is not subject to heavy scour or change of channel. It carries heavy drift at times of flood, and has sufficient current to cause logs to dive when striking an obstruction, making submerged pile foundation dangerous. It was decided for various reasons to use an open caisson or cofferdam rather than a pneumatic caisson.

This double-walled caisson or cofferdam was to penetrate 10 ft. below the bed of the river, and surround the cylinder cluster. The interior space was then to be filled with piles driven as far below the cutting edge as possible; it was then to be sealed with concrete, pumped out, and the piling, as well as the six small cylinders, cut off, all to be capped with a grillage of square timber; this timber to surround and be fitted to the central cylinder; the central cylinder then to be cut off 2 ft. from the top of the cofferdam, and upon the grillage a cylinder to be erected 24 ft. in diameter and 44 ft. high, of riveted steel plates, filled with concrete, and surrounded with a limestone coping 24 ins. thick. The lowest bid made for the construction exceeded the estimate by 40%, and, after a careful reconsideration by the manager, the writer was authorized to proceed with the work with the regular company forces. It was completed according to the plans and specifications, at a total cost of 85% of the original estimate, and only 60% of the lowest bid received.

Active work was begun Dec. 18. In the removal of obstructions a diver was employed to assist in the work. To protect the cofferdam from current, a breakwater of V-shape was made 175 ft. upstream, with the wings flaring out slightly beyond the sides of the cofferdam. About 100 ft. upstream from the nose of the breakwater two pine piles were driven and chained together; a wire rope was made fast to these at the bottom, carried downstream and attached to the nose of the breakwater as a guy. The cofferdam was braced against the pivot pier, but was supported against the current by wire cables 1¼ ins. in diameter, which were led from the different anchor straps on both sides of the nose of the breakwater. By means of adjusting screws sufficient strain could be put on the cables to hold the cofferdam in position or twist it, as occasion might require.

The temporary trestle was stiffened to resist floods by six cables 1¼ ins. diameter, fastened to trees on the bank, upstream. The shoe was made in four sections, and while putting it in place around the pier and building the first four courses of wall upon it, the weights were supported by two barges, and eight crab winches stationed on the platform of the trestle overhead. The work was begun Feb. 14. The shoe was then filled with concrete, and on Feb. 18 it was lifted clear of the barges and lowered into the water until all but the top part of the timber was submerged. The cofferdam was 28 ft. square in the clear inside, and 33 ft. 4 ins. outside. The double walls consisted of 10 × 10 in. timbers 32 ft. and 34 ft. long. Each course of timber was drift-bolted to the ones below by ¾ × 22-in. iron drift bolts. Strut blocks were inserted at alternate courses between the double walls, the clear space between the walls being 12 ins. A ¾-in. bolt passed through each block and the walls to draw them tightly together. The iron shoe was of V-shaped cross-section, with the line of the outside plate vertical. The construction was continued by adding more wall timbers, filling with concrete and lowering into water as the successive courses were added, but always retaining considerable weights on the suspending chains, as the caisson was more manageable when handled in this way.

The cofferdam reached bottom on March 4; 44 courses of timber wall having been built on top of the shoe, making a total height of 40 ft. 8 ins. In sinking the caisson a strong jet of water was forced through a nozzle, directed by a diver who worked inside of the cofferdam; this was used to jet the material away from the cutting edge and toward the four corners of the cofferdam. The cofferdam was continued to a height of 48 ft., or 52 ft. above the cutting edge. Sand bags were used outside of the cofferdam to stop scour which happened to prove serious.

On April 4 the cutting edge reached 10 ft. below the river bed. Gunny sacks, filled with concrete, were then placed inside and underneath the overhang of the shoe, and outside and against the walls in the ditch which had been formed, after which the ditch was filled with stiff clay, on top of which riprap was placed. After removing the cribbing, etc., piles were driven with a 3,000-lb. hammer. The piles were 55 ft. long, with not less than 10 ins. of heart at the small end. By the weight of the hammer and the aid of the jet they would settle from 10 to 15 ft., after which they were driven to a depth of 23 to 24 ft. below the cutting edge of the cofferdam.

The sand displaced by the driving of the piles rose to a height of 6 or 7 ft. above the cutting edge inside of the cofferdam. The piles were then capped with grillage; Portland cement concrete 2 ft. thick was deposited around the piles, and above this Louisville cement concrete to within 1 ft. of the height at which they were to be cut off. The cofferdam was very tight and was kept clear of water by a small amount of pumping. The walls supported, without bracing, a depth of 16½ ft. of water on the outside. After the placing of the grillage a place was made level on its top for the 24-ft. cylinder. This was made water-tight, so that concreting could be carried on inside of it in the open air. As fast as the cylinder segments were placed the interior was filled with concrete well rammed and the work was completed, ready for the coping, in 26 days from the time of the placing of the first segment.

CONTRACTORS' PLANT AT THE WORLD'S COLUMBIAN EXPOSITION.

The exhibits of machinery and appliances of interest to contractors were very numerous and extensive, and in the present article we give some particulars of the fixed plant, such as hoisting engines and derricks, pile-drivers, steam shovels, rock drills, etc. In previous issues we have already given particulars of other exhibits of contractors' plant, including dump carts, grading machines and scrapers, rollers, rock crushers, wire rope tramways, etc.

Hoisting Plant.

The American Hoist & Derrick Co., of St. Paul, Minn., had an interesting exhibit of hoisting plant and derricks, shown in Fig. 1. The hoisting engine shown was a two-cylinder engine with horizontal drum for raising and vertical drum driven by bevel gearing for turning the derrick post, the wire rope round the latter drum passing round a bull wheel at the foot of the derrick post. All movements were effected by friction clutches. The vertical boiler was of the submerged flue pattern, which is one of the company's specialties. A water chamber surrounds the top ends of the vertical tubes and the top tube sheet. A large tubular derrick was shown, of the style illustrated and described in our issue of Nov. 28, 1891, and Feb. 2, 1893, and there were also crane and stiff-leg derricks. The crane derrick had a 65-ft mast, 59-ft. horizontal boom and had a lifting capacity of five tons. The whole derrick was operated by steam power, which raised the load, turned the mast, and ran the trolley of the hoisting rope the entire length of the 50-ft. boom. The boom was made of two parts, held the right distance apart by three yokes, and upon the upper side of the boom were steel T-rails, upon which the trolley runs. The boom was elevated at the outside end about 18 ins., which assisted in allowing the trolley to travel toward the mast, and the trolley was also counterweighted by a weight hanging near the top of the mast. At the foot of the mast was an iron bull wheel, 8 ft. diameter, driven by a wire rope making two turns round and thence back to the turning winch connected with the engine, shown in the cut. The 10-ton tubular derrick was made entirely of iron, the mast and boom being of pipe and the crosstrees and truss rods of wrought iron. The boom was 75 ft. long, mast 80 ft. high, and the capacity of this derrick was 10 tons. At the foot of this was a bull wheel similar to the one above described. A derrick similar to this one is in operation at the Henry R. Worthington works, formerly at Elizabethport, N. J., but the mast is but 50 ft. high and the capacity only five tons. It is operated with a double-drum 20-HP. electric hoist and is not furnished with a bull wheel and turning winch, as were the derricks at the Exposition. In the stiff-leg derrick exhibited, the hoisting line was operated by power and the boom line by hand power. The boom of this derrick was 40 ft. long and the capacity was five tons. The exhibit also included a vertical hoist for building purposes, etc., with elevator platform traveling between guides; horse power duplex hoisting gear, rock drills and flexible joints for steam pipes.

The Industrial Works, of Bay City, Mich., exhibited seven locomotive cranes, five of which were of 7 tons capacity and two of 12 tons capacity. One of the latter is shown in Fig. 2. The frame is about 18 ft. long and 9 ft. 3 ins. wide, built up of I-beams, plates and angle iron, and having the end sills protected by oak timbers. The front end is carried by a truck of the Thielsen pattern, with 33-in. wheels, and built to the M. C. B. standards, while similar wheels and axles, with boxes in rigid pedestals, support the rear. The car is equipped with draft gear and hand brakes. To afford additional support in heavy hoisting, there are steel outriggers sliding upon rollers, which can be extended on either side to a distance of 4 ft. Jackscrews and four track clamps are used with these. The base casting attached to the car body supports two cast iron A-frames, which carry the gearing and shafting, the whole revolving about a hollow center pin which takes a tensional strain in lifting, the thrust of the load being then received by steel rollers traveling on a path on the base casting. A double-cylinder reversing engine supplies the power for all motions: for hoisting, through a drum with gearing and clutches; for varying the jib radius, through a worm and wheel; for slewing, by means of a pinion and circular rack on the interior of the base casting; and for propelling, by a vertical shaft passing down through the center pin and driving the rear axles by a chain and gearing. At the rear of the A-frames is a vertical boiler, with coal bunker and a water tank of 200 gallons capacity. This weight acts as a counterpoise. The jib swings from the front of the A-frames, and is composed of two I-beams, braced together and having the ends curved. The ordinary radius of jib is from 13 to 20 ft. The smaller cranes are of generally similar construction, with frames 10 ft. 6 ins. long and 7 ft. wide, carried on four 33-in. wheels with M. C. B. axles and rigid pedestal jaws. The cylinders are 6×10 ins. The several motions are as described for the larger machine. Mr. W. H. Holcomb, General Manager of the Exposition, stated in August that these seven cranes were selected for the purpose of unloading, placing in position and shifting carloads of exhibits. They were in use three months preceding the opening of the Exposition, and during this time they gave entire satisfaction. There were handled in the different departments 119,046,697 lbs. of exhibits in 355,520 packages, and 7,281 cars. Of these packages, such as were not easily handled otherwise, were lifted and transferred by these machines. The same builders also furnished an electric transfer table, constructed of 15-in. steel I-beams and carried upon 16 flat-tread wheels 36 ins. diameter. The power was applied through a 30-HP. single reduction motor, and loads of 110 tons were easily carried. This machine was used in the Transportation Building, running from end to end of the annex, and handled all of the locomotives and cars in that building. One of the railway transfer tables, built by these works, was illustrated and described in our issue of Feb. 20, 1892.

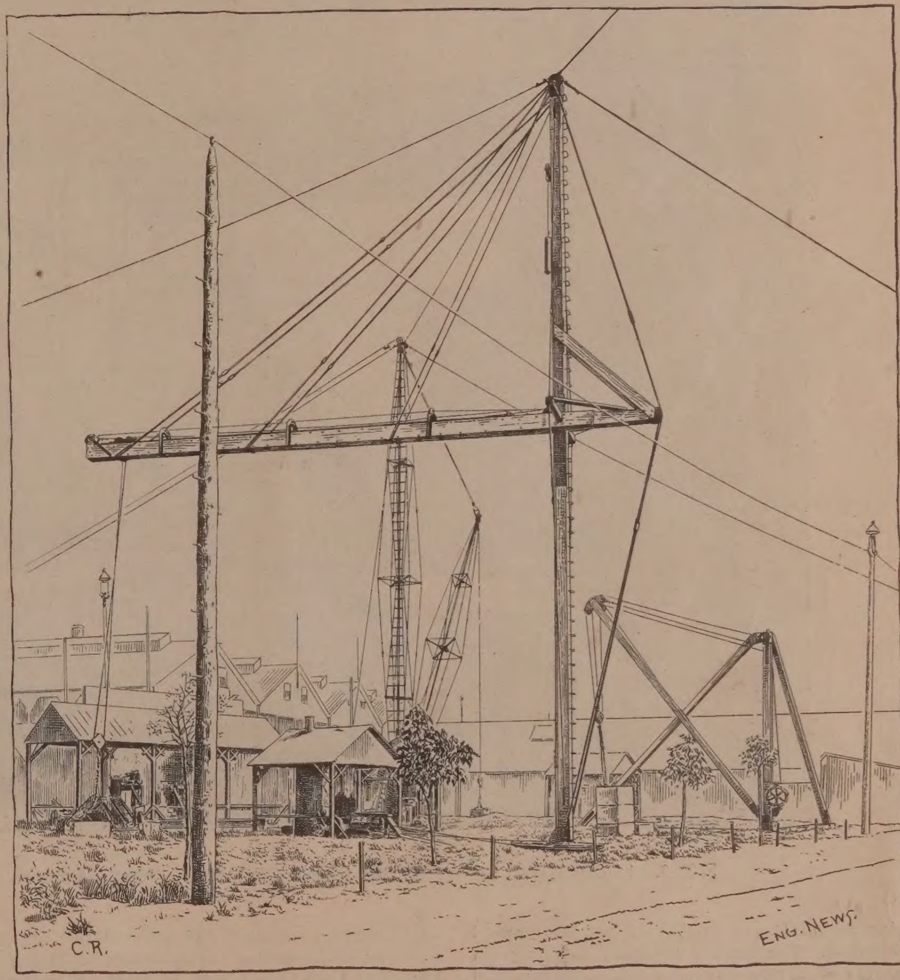


FIG. 1. CRANES AND DERRICKS OF THE AMERICAN HOIST & DERRICK CO., ST. PAUL, MINN.

The Yale & Towne Mfg. Co., of Stamford, Conn., exhibited a four-wheel locomotive crane of a similar type to that above described, but propelled by shafts and steel bevel gear to all wheels, instead of by chains. The jib is straight and the motions are all effected by friction clutches. The company also furnished one of the three overhead traveling electric cranes in the Machinery Building, weighing 58 tons, with a span of 75 ft., and having a lifting capacity of 20 tons and a traveling capacity of 500 ft. per minute, with a travel of 1,400 ft. (Eng. News, April 13, 1893). The other two similar cranes in the Machinery Building were furnished by the Morgan Engineering Co., of Alliance, O., and W. Sellers & Co., of Philadelphia, Pa. Hoisting engines and mining hoists were exhibited by the Lidgerwood Mfg. Co., of New York, together with an erecting engine of the type illustrated and described in our issue of Feb. 6, 1892. The General Electric Co. showed an electric derrick and magnetic hoist with a magnet of 2,000 lbs. lifting capacity. James Boyd, of St. Paul, Minn., exhibited a vertical elevator for materials in construction works, in which the cage or platform runs on guides of wire rope or gas pipe. It was operated by a double-cylinder reversible hoisting engine, fitted with vertical boiler and patent friction drum.

Steam Shovels.

Three makes of steam shovels were exhibited, representing standard practice in such machines for railway and other work. The Bucyrus Steam Shovel & Dredge Co., of South Milwaukee, Wis., exhibited two boom excavators (Eng. News, Nov. 16, 1893). The larger one, weighing 30 tons, had an iron boom and wooden dipper arm carrying a dipper or bucket of 1¾ cu. yds. capacity. It had a horizontal engine, with two cylinders 8×12 ins., and was self-propelling by means of a link belt driving chain. It was carried on two Fox pressed steel trucks. The smaller machine, weighing ten tons, was of narrow gage, not self-propelling, and was carried on a pair of diamond trucks. The boom and dipper arm were of iron, carrying a dipper of ⅓ cu. yd. capacity. The horizontal engine had two cylinders, 5×8 ins. This company also exhibited the largest dipper bucket in the world, of 8 cu. yds. capacity, and a model of a ladder dredge, together with specimens of the buckets for such a dredge, of ⅓ cu. yd. capacity, fitted with the protected and lubricated joint connections, invented by Mr. Robinson, Chief Engineer of the company. The Marion Steam Shovel Co., of Marion, O., exhibited one of its Barnhart steam shovels (Eng. News, April 27, 1893), carried on diamond trucks and self-propelling by means of chain gearing to both trucks. The arm and boom were of wood, and the engine was vertical. At each front corner of the machine was an outrigger arm, braced to the frame and fitted with jackscrews at the ends resting on the ground, to steady the machine in heavy work. The company also exhibited a ballast plow and a horizontal winding engine. The Vulcan Iron Works Co., of Toledo, O., exhibited one of its Little Giant machines (Eng. News, May 4, 1893), not intended for use on railways, but fitted with broad tired carrying wheels.

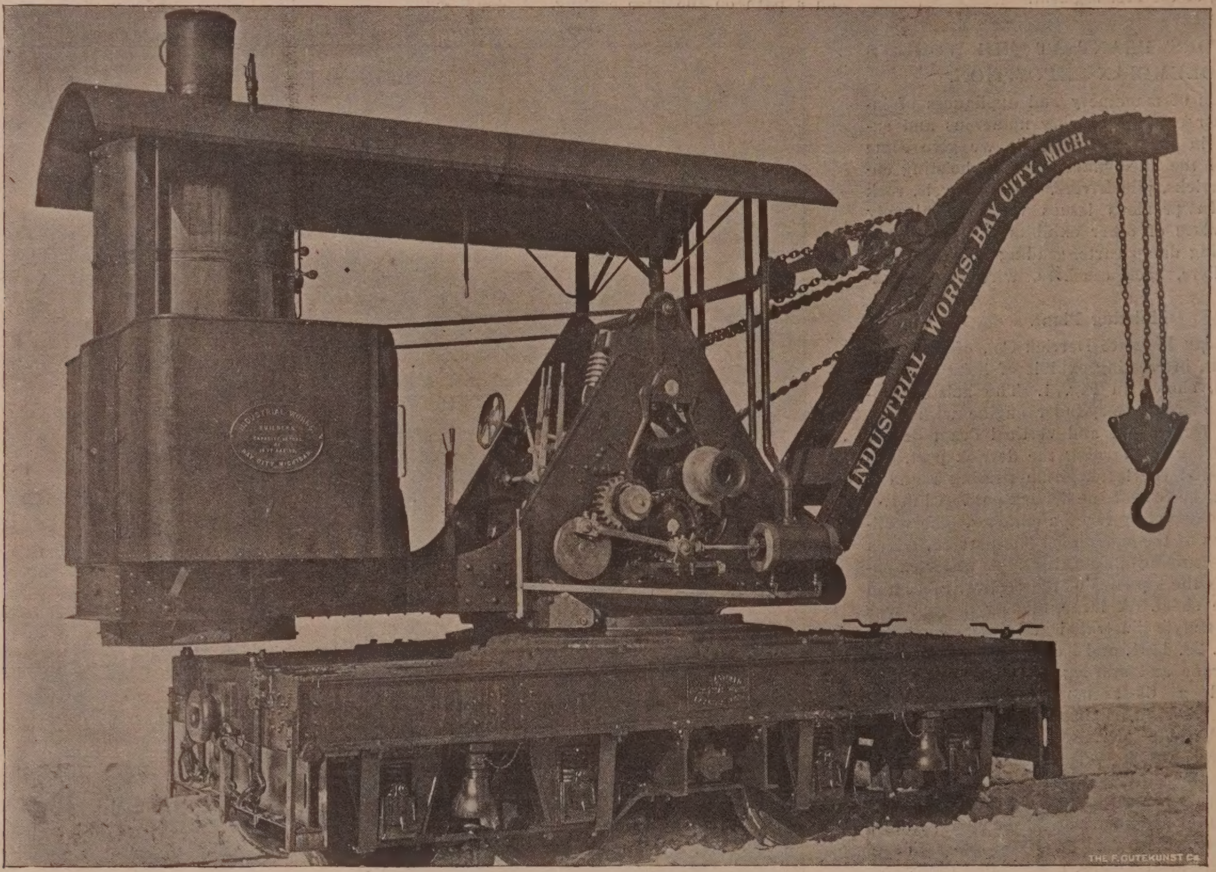


FIG. 2. LOCOMOTIVE OR WRECKING CRANE OF TWELVE TONS CAPACITY. Industrial Works, Bay City, Mich.

Pile-Drivers and Piling.

In an annex to the main boiler-house behind the Machinery Building were two large pile-drivers exhibited by the Vulcan Iron Wroks, of Chicago. One of these was an ordinary drop hammer machine, operated by a rope and winding engine. The other was a Vulcan-Nasmth steam pile hammer, in which the hammer rests upon the pile and moves in guides in the ordinary leaders of the derrick frame. One of these machines was used in driving the test piles for the foundations of the Chicago Public Library, as described in our issue of July 6, 1893, and we shall illustrate it in a later issue. The Wakefield Sheet Piling Co., of Chicago, exhibited specimens of its triple lap piles, each consisting of three planks bolted together so as to form a tongued and grooved pile, as described and illustrated in our issues of March 1, 1890, and April 16 and Sept. 15, 1892. F. Schmidt, of Altona, Germany, showed models of iron sheet piling, as used at Cuxhaven Harbor. The piles are of elongated elliptical section, and are filled with concrete after being driven.

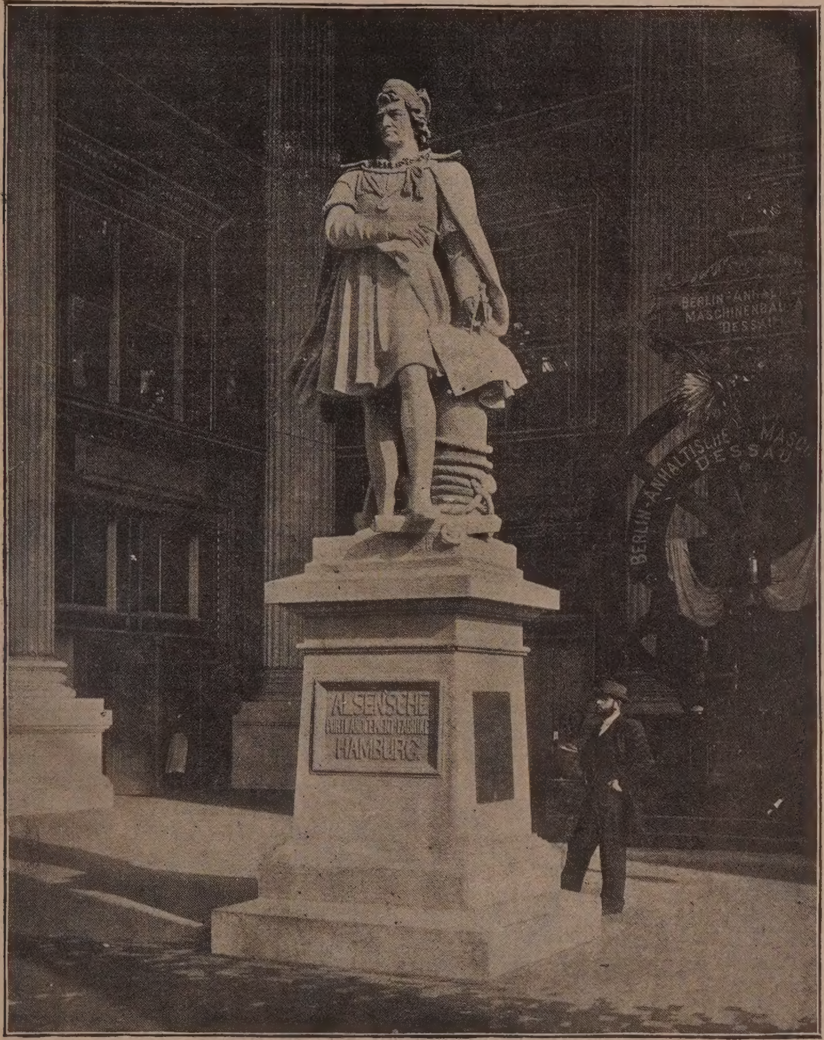
Rock Drills and Channelers.

The exhibits of this class of machinery were quite extensive, but represented well known and standard patterns, rather than any particular novelties. The Rand Drill Co., of New York, showed its "Slugger" and "Little Giant" drills of various patterns and sizes and also a drill for tapping blast furnaces (Eng. News, Nov. 3, 1892). A model was shown of I. W. Fowler's drill made in 1851, the first in which the cutting bit was an extension of the piston rod, and this drill had the principal parts of the rock drill now in use, including rotation by a spiral and ratchet feed. The Ingersoll-Sergeant Drill Co., of New York, had a large exhibit, including drills, channeling and gadding machines, coal mining machines, etc., together with air compressing plant. The Bullock Mfg. Co., of Chicago, had a number of diamond core drills for boring holes 1¾ ins. and 2 ins. diameter, and 500 to 1,500 ft. deep, and a giant diamond drill for depths of 5,000 ft. These drills are largely for prospecting work, and may be driven by steam, compressed air, hand or horse power. The Sullivan Machinery Co., of Chicago, exhibited core and diamond drills, gadders and coal cutters, and the Wardwell stone channeling and quarrying machine was exhibited by the Steam Stone Cutter Co., of Portland, Vt. The Beal Mining Core Drill Co., of Elyria, O., exhibited a portable drilling rig for prospecting, etc., having the boiler, engine and derrick carried on a frame mounted on four wagon wheels. The McKay Electric Reciprocating Tool Co., of Boston, Mass., exhibited a reciprocating rock drill, in which a sliding commutator sends the circuit alternately through an upper and lower magnet, the circuit being merely changed and not broken, so that the machine could be connected to an incandescent light circuit. The General Electric Co., of New York, had also electric drills, of the type illustrated and described in our issue of May 25 last.

EXHIBITS OF ALSEN'S PORTLAND CEMENT AT THE COLUMBIAN EXPOSITION.

One of the exhibits of Portland cement at the Columbian Exposition which attracted most attention from engineers and builders was that of the Alsen Portland Cement Works, of Hamburg, Germany. The chief interest of this exhibit lay in its illustration of the variety of uses to which Portland cement is put in Germany, and especially its adaptibility to the decoration of buildings and the construction of ornamental statuary for parks and public squares. The most noticeable feature of the exhibit was perhaps the statue of Columbus which stood at the main entrance to Machinery Hall, and which is shown in the accompanying illustration.

This statue was designed by one of the most prominent sculptors of Germany, and was intended to be cast in bronze, and erected in 1892 by the city of Hamburg, in the public square, in commemoration of the discovery of America by Columbus. The severity of the scourge of cholera which visited that city last year, however, interfered



STATUE OF COLUMBUS CAST IN ALSEN'S PORTLAND CEMENT AT THE COLUMBIAN EXPOSITION.

with the consummation of this purpose, and it was abandoned. The Alsen Portland Cement Works, of Hamburg, then purchased the model of the statue, and had it cast in Portland cement of their own manufacture, and sent it to the United States as part of their exhibit at Chicago. The main exhibit of the company also included a somewhat larger group of statuary and numerous statuettes, gargoyles, bas-reliefs, etc., in a separate pavilion.

The possibilities of beton-coignet in cast blocks for ornamental work have long been known, and it is very commonly used in France and other European countries, mostly for outside decoration of buildings and masonry for park bridges and terrace walls. The advantages of Portland cement, used neat, for similar work, especially for the finest and most delicate work, have hardly been recognized outside of Germany, and the exhibit of this nearly perfect cast cement work was, therefore, unusually interesting.

CONSTRUCTION OF THE RIVER PIERS FOR THE MEMPHIS BRIDGE.

In our issue of May 12, 1892, we gave a general description of the main features of the Memphis Bridge, and in succeeding issues described in detail the ironwork of the superstructure. The accompanying cuts, reproduced from a paper presented before the Institution of Civil Engineers by Chief Engineer Geo. S. Morison, M. Inst. C. E., illustrate the caissons and pneumatic appliances used in sinking the two river piers, which had unusually deep foundations and which constituted the most difficult portion of the foundation work. The following details in regard to the work are abstracted from Mr. Morison's paper:

The bridge, as built, crosses the river with one span of 790 ft. 5 ins., and two spans of 621 ft. ¾ in. between centers of piers. The three spans rest upon four masonry piers, two of which are near the low water shore lines, and may be properly termed shore piers, and two in deep water, and are properly river piers. The east pier is known as Pier II., and the west pier as Pier III. (Fig. 1). The plans of the two piers were prepared in January, 1889, and the data from which their character was decided upon were a set of borings which had been made two years previously, and such information as had been obtained during the sinking of the caisson of the west shore pier. Soundings had shown the bottom of the river to be 145 ft. above datum at the site of Pier II., and 160 ft. at the site of Pier III. The borings had found clean river sand to 98 ft. above datum, near the site of Pier II., and to 108 ft. at the site of Pier III. At these levels clay was encountered, which, at the higher levels, was somewhat variable in quality, but into which one boring was made down to 61 ft. above datum. This clay forms part of an immense deposit, known as the La Grange formation, which is about 150 ft. thick, and perfectly water-tight. Under this clay lies water-bearing sand or gravel, the outcrop of which is perhaps 50 miles east of Memphis, and at a somewhat greater distance west of that city. A cross-section of the river, showing the material found by the borings and in the caissons, is given in Fig. 1.

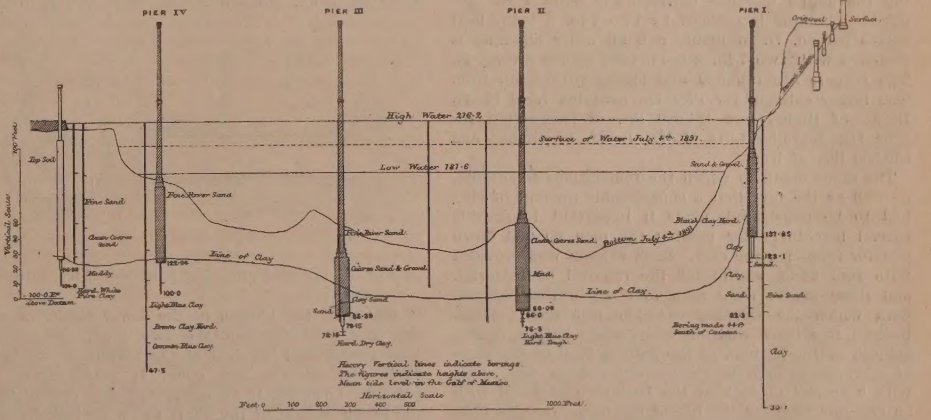


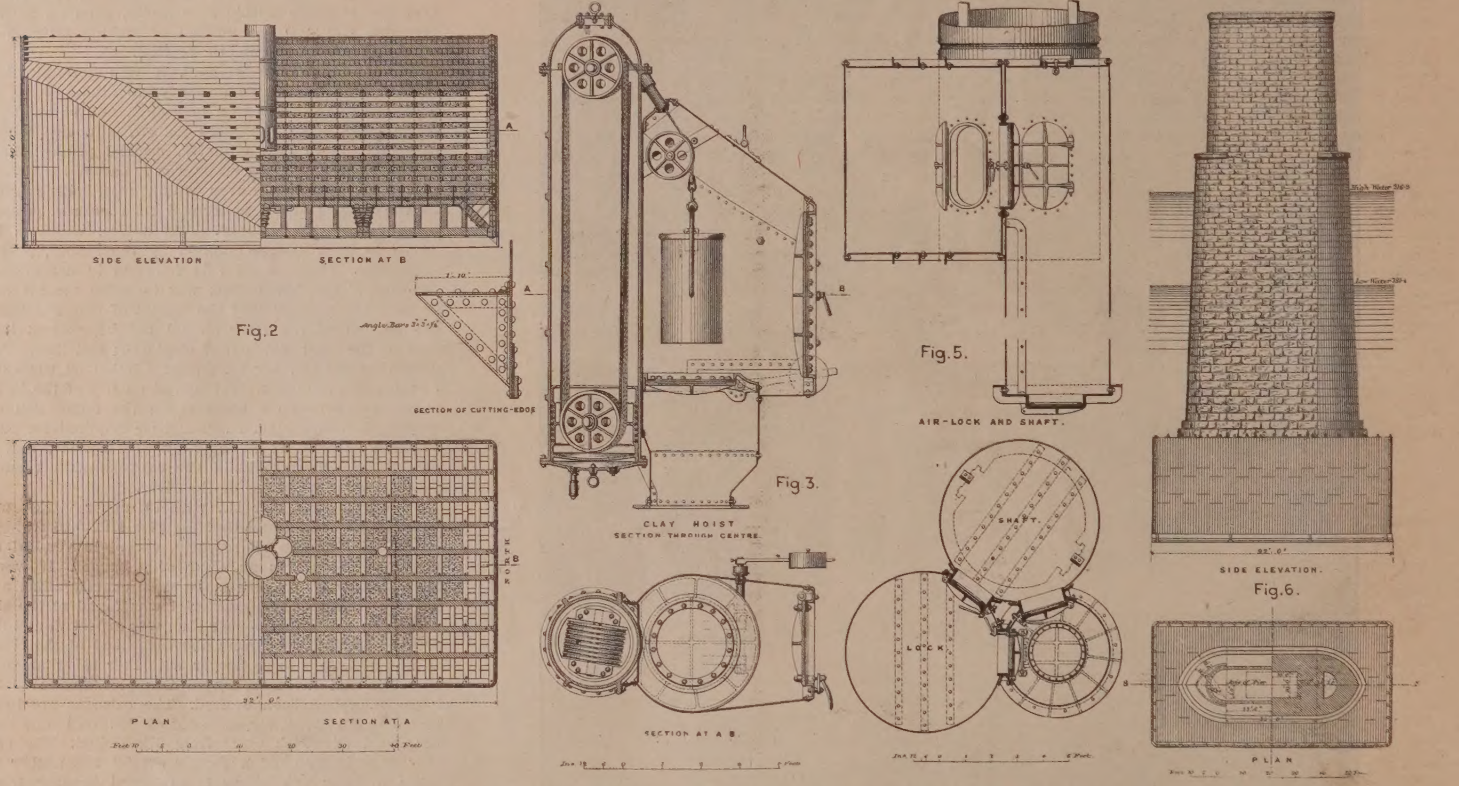
FIG. 1. PROFILE OF FOUNDATIONS FOR THE MEMPHIS BRIDGE.

It was evident that the foundations must be sunk through the sand and into the clay, and that, whilst it was important to secure a thorough bearing everywhere on this clay, it was probably so compact that difficulty would be experienced in any attempt to dredge it. Plans were therefore made to meet the four requirements: (1) The weight of the piers to be limited as much as possible; (2) provision to limit the scour, at least during the construction of the work; (3) the base of the foundation to be large enough to keep the pressure within safe limits, even on a compressible clay; (4) the method of sinking selected to be the "plenum" pneumatic process.

To keep down the weights, it was determined to build a high quality of masonry, to diminish the dimensions of the piers to a minimum, and to build the lower portions of the piers hollow, a device which, objectionable in cold climates, seemed prudent here. The method of limiting scour was to carpet the bottom of the river with a woven willow mat, built floating on the surface of the water and then sunk in position by loading it with riprap. This device, which is believed to have been originated by the author, proved successful. The general rule followed in determining the size of the foundations was to make the caissons of such construction that the weight of material below the bottom of the river should not be greater than that of the sand which they displaced; and that, after deducting 400 lbs. per sq. ft. for friction on the sides of the caissons, the weight placed on top of the latter should not produce a pressure on the foundation exceeding 2 tons per sq. ft. The base required for such foundations was 92 ft. long by 47 ft. wide, and it was thought best to build the caissons with vertical sides below the bottom of the river.

The caisson for Pier II., with its upper works, was made 59.4 ft. high, and that for Pier III., 39.6 ft. high, both being alike in all respects, except in vertical dimensions. This was an error of judgment. It would have been wiser to have made them exactly alike, and each 50 ft. high. Good material was found at the site of Pier II., a few feet higher than was expected, and the square foundation projects above the bed of the river. It was necessary to go deeper with Pier III. than with Pier II., and the masonry of this pier begins 10 ft. lower than had been desired. The caissons are illustrated in Fig. 2. They are built of Southern pine timber, most of which came from Mississippi. The cutting edge is iron, of a form used by the author at other bridges; this shape is preferred because it at once permits access to the actual edge when obstacles are encountered, and provides a shoulder on which the caisson can bear when sinking through sand, the edge that projects below this shoulder preventing an influx of sand from without. The V-shaped walls surrounding the working chamber, and the entire space between the timbers for a height of 17.3 ft. above the bottom, were filled with concrete after the caisson was placed in position. Above this concrete filling, for a height of 26.7 ft. in Pier II., and 11.9 ft. in Pier III., the interior portion only of the structure was filled with concrete, the outer parts being left empty. The upper 15.4 ft. in Pier II., and the upper 10.4 ft. in Pier III., are of solid timber.

The vertical side walls are bound together by 54 2-in. rods, the lower lengths of which pass through the timbers, the nuts being screwed against the under side of the shoulder of the cutting edge and against washers on the top; in the upper part of the work, these rods are placed immediately inside the timbers. There are also 24 2-in. rods similarly placed in the cross walls, and connected with 1½-in. rods extending through the concrete. Besides these, 112 rods of the latter size extend from the roof of the caisson to the top of the concrete, near the timber intersections; and the inclined walls of the caisson are tied to the outside vertical walls with 96 rods of similar section passing across the V-shaped space. The sides of each cross wall are tied together by 36 1-in. bolts, and the timbers of the roof are tied together by 390 1-in. bolts. The successive courses of timber in the outer walls are fastened together with 1-in. round drift-bolts 34 ins. long, spaced 5 ft. apart; and as these bolts alternate in successive courses, the actual distance between them is only 30 ins. The timbers of the inclined walls of the working chamber are fastened with drift-bolts 30 ins. long, spaced 3 ft. apart; and the cross walls are fastened with drift-bolts in the same manner as the outer vertical walls. The timbers of the solid filling above the concrete are fastened with 34 1-in. drift-bolts, spaced 8 ft. apart in every stick, thus making the actual distance between the bolts 4 ft. The outside planking is secured by two 7-in. × ½-in. boat spikes per sq. ft. of plank, and all other planking is fastened with two 7-in. × ⅜-in. boat spikes per sq. ft. The corners are rounded and plated with ⅜-in. iron. The larger caisson, for Pier II., contains 1,548 M ft. B. M. of timber and 424,000 lbs. of iron. That for Pier III. contains 1,078 M ft. B. M. of timber and 340,000 lbs. of iron.



DETAILS OF CAISSONS, AIR LOCKS AND HOISTS USED IN SINKING FOUNDATIONS OF RIVER PIERS, MEMPHIS BRIDGE.
Chief Engineer, Geo. S. Morison, M. Am. Soc. C E.

The great depth to which the foundations were sunk, as well as the fact that a considerable amount of clay had to be penetrated, made it important to provide special machinery for passing the men up and down and for removing the clay. Each caisson was provided with four 24-in. shafts for the removal of material, and these shafts were used to send in the concrete with which the working chamber was finally filled. Besides this there was one 36-in. shaft with a double air-lock at the bottom, of the pattern used on the piers of other works built by the author; and one 6-ft. shaft with a special air-lock at the bottom, and fitted with an elevator cage for the use of the men. Besides this, the usual provision was made of pipes for air and water supply, and for the removal of sand.

The device selected for the removal of the clay was what is known as a "clay hoist." This arrangement is shown in detail in Fig. 3. It consists of an air-lock at the top of the shaft, behind which is placed a cylinder and piston; the speed of the piston is multiplied by two sets of sheaves, so that the stroke of the piston will lift a bucket from the bottom of the caisson to the air-lock on top; the air-lock is provided with two doors, one of which, opening into the shaft below, is closed by a lever with a balance weight on the outside, and the other, opening into the open air, is worked by the attendant outside. The only power used is the air pressure of the caissons. The bucket carried 6½ cu. ft., and 12 buckets have been passed out by a single hoist in an hour. Four hoists were provided, but no more than two were ever used at a time. Fig. 4 shows the form of sand pump used in the caisson to remove sand by a column of water. It is the same in principle as the Eads pump used at the St. Louis Bridge, but is much simpler in construction. The special air-lock and passenger hoist are illustrated in Fig. 5. The latter is simply a hoisting engine placed on the top of the working shaft, and so arranged as to be taken off with a derrick and quickly replaced when it was necessary to add a section to the shaft. The engine has large cylinders, and instead of being driven by steam, is driven by air from the caisson. The upper shaft through which the elevator cage runs is a cylinder 6 ft. in diameter, the air-lock is 6 ft. in diameter, and the shaft leading to the caisson is 4 ft. in diameter. These three cylinders are side by side, the shells being connected by cast iron door frames carrying doors, while a fourth door opening outward is placed at the bottom of the lower shaft; in working, the door between the two shafts was always kept closed, and the door at the bottom of the bottom shaft was always left open. It would have been possible, however, if an emergency had arisen, to use the lower section of the shaft as an air-lock by itself. When the filling of the working chamber was completed the bottom door was permanently closed. The only power used to raise either men or material was the air of the caisson; and while this arrangement may not be as economical of power as the direct use of steam, it had the advantages of convenience and of improving the ventilation of the caissons.

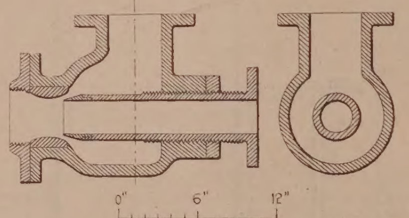


Fig 4 Sand Pump Used at Memphis Bridge.

It was hoped that the two foundations might be completed during the low water season of the autumn of 1889, a hope destined to be disappointed. The first timber for the caissons was received on April 1, 1889, and framing was begun on the 18th of that month. The timber was received in a yard on the east side of the river, about 2,000 ft. below the bridge line. A Daniels planing machine was used to size the timber in the yard, the 12-in. timber being thus reduced to 11¾ ins.; this reduction explains the slight irregularity in vertical dimensions. All other work was done by hand with ordinary carpenters' tools. The caissons were put together on launching ways, being built directly in front of the framing yard, and at the edge of the water. The foundation of these ways was of cypress piles driven about 25 ft. into the ground. The piles were cut off and capped with 12-in. square timbers running parallel with the river, and on these were placed the ways proper, which were drift-bolted to the caps and inclined at 1 in 4 for a length of 48 ft., and at 1 in 3.43 for the remainder. The launching shoes, which were simply transverse timbers, were placed on these ways, the cutting edge was set up on the shoes, and the caisson was built up to a height of 17.8 ft. from the lower edge of the iron in this position.

The building of the caisson and the construction of the lower portion of the ways proceeded simultaneously. The ways were completed on July 27, and two days later the caisson for Pier II. was successfully launched. The caisson was fitted with a false bottom, which, however, was simply intended to prevent the lower edge from settling too rapidly in the water, and was not made tight. When the caisson was launched it drew about 12 ft. It was then kept near the bank until the condition of the river admitted of its being put in position. The caisson for Pier III. was meantime constructed and was launched on Oct. 26.

Before the caissons could be placed in position, the mats which were to protect the pier sites from scour had to be placed. Two barges were fitted with ways for weaving the mats, and two mooring barges were anchored above the site of the pier, across the stream. The weaving barges were then placed below the mooring barges, and the material barges were brought to the lower side of the latter. The mat was then woven on the ways, and the upper end of it was fastened to the mooring barges and to the anchors which held them—each anchor having one line leading to one of the mooring barges, and another line leading under the mooring barge to the mat. As the weaving proceeded the weaving barges dropped downstream, so that when the mat was entirely completed they were at the lower end, and the whole mat, 240 ft. wide and 400 ft. long, was floating on the water. It was then loaded with stone until it barely floated, and the upper end was submerged, but held near the surface by the lines leading from the mooring barges. Two barges

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loaded with stone were then brought to the upper end of the mat, and stone was thrown from them upon it; as it sank the barges were dropped downstream until the mat settled on the bottom. When these barges had passed over about one-half the length of the mat the mooring lines were cast off and the upper end was allowed to sink to the bottom. The time required to sink the mat did not exceed 10 minutes. In the case of the first mat sunk, soon after the upper end had been dropped on the bottom, the anchors dragged and the mat took position about 120 ft. farther downstream then had been intended. Two mats were placed at the site of Pier II., each one containing 1,000 cords of brush and poles, 900 tons riprap and 10,000 lbs. of wire.

To facilitate handling the caisson in position two special barges were anchored above the pier site, the lines by which the caisson was held were fastened to these barges and a double-drum winding engine on one of them was employed to haul the lines. The anchors used were of the pattern known as box anchors, consisting of timber cribs, each 10 ft. cube inside the timbers, filled with stone. They were built on barges, thrown overboard at the place where they were wanted and were never recovered. Each barge was held by six steel wire ropes 1¼ in. in diameter, leading to separate anchors, so that 12 anchors and 12 wire cables were used for one caisson. On Sept. 23, these anchorage arrangements having been completed, the caisson for Pier II. was brought into position and was held at first by two wire ropes leading to the anchor barges. It was also anchored laterally by a 4½ in. manilla rope, passing from each of two anchors situated about 500 ft. distant on either side of it, through snatch-blocks, to one of the anchor barges above. This method of anchoring and handling the caisson was devised and carried out by Mr. Noble, the Resident Engineer.

Fortunately, the current in the river was slight at this time, and no special difficulties were experienced in placing the caisson. After it was securely anchored the concrete filling of the spaces above the working chamber was begun and the building of the upper works was carried on at the same time. As this proceeded, the number of anchor lines leading from the caisson to the barges was increased until their strength was about the same as that of the lines from the barges to the anchors. On Oct. 7 the caisson grounded at 151.6 ft. above datum in 36 ft. of water. Air pressure was applied on Oct. 10, and 14 days were spent in cutting away and removing the two thicknesses of mat underneath the caisson. Meanwhile the concrete filling was completed and sinking proceeded regularly from this time, the sand being excavated by columns of water driven through sand pumps. On Oct. 23 the laying of masonry was begun; but, on Nov. 30 all work was suspended for 10 months, the water having risen to such a height that it was considered inexpedient to do more at present. The shoulders under the cutting edge were blocked and the foundation was abandoned until the low water season of the following year.

The situation of Pier III. was considered to be less exposed than that of Pier II., and one mat only was woven for this pier. The caisson was brought into position without serious trouble, and the concrete filling was begun on Nov. 5. The river had already begun to rise and it continued to do so until Nov. 25. These three weeks formed the most critical time of the entire work. During the rise of the water the current in the river made an angle of about 10° with the axis of the pier and tended to move the caisson toward the west. On Nov. 19 the caisson was 20 ft. out of place; by the aid of two tugs and of five lines leading to Pier II. it was brought within 5 ft. east of its true position; four days later all the lines leading east and one of the northeastern lines parted and the caisson was carried 50 ft. west of its true position. Five coils of wire rope were brought from St. Louis, 350 miles, in one night; and anchors were added until the caisson was held by 18 wire ropes upstream and five leading eastward. With these lines the caisson was brought into correct position and held there until it was completely sunk on Dec. 10 in 44 ft. of water. On the following day the caisson and upper works were completed. It had been necessary to build up the sides of the caissons before putting in the solid timber, and to carry it up 4 to 6 ft. above its intended height by false sides. The caisson had been saved and no serious loss experienced. Its safety may be ascribed to: first, the mat which prevented the deepening of the bottom; and second, the strength of the anchorages. Air pressure was applied, the mat was cut through and sinking was conducted in the same manner as at Pier II. until the clay was reached on Feb. 7, 1890. One week later work was suspended until the river should be in a condition more favorable to the work. Before stopping work, borings had been made below the edge of the caisson and a well sunk into the clay, which proved to be of a less substantial character than had been expected, and it became evident that the foundation must be carried lower than was originally intended.

By the middle of June the water had fallen sufficiently for work to be resumed, and on Sept. 4 the foundation was completed at a depth of 18 ft. lower than had been originally intended. The masonry was completed on Jan. 23, 1891. The increased height of the pier was made entirely in the masonry, the batter being correspondingly reduced.

In September, 1890, work was resumed on Pier II.; no work had been done on it for eight months, and for more than three months the entire work had been submerged. The cutting edge of the caisson reached its final level an Oct. 16. An experimental well was sunk to 86 ft. above datum, and a boring was made from the bottom of this well 10 ft. lower. The whole pier, including the masonry, was finished on April 25, 1891. This foundation had been sunk 6 ft. less than had been expected, and the difference required for correct dimensions was obtained by a slight offset in the masonry.

The entire work on the foundations was done by men employed by the bridge company, the number of men worked on the foundation sometimes amounting to 160. When the work was begun the caisson force was divided into three gangs, each of which worked eight hours in four-hour shifts; but as the depth increased the working hours were shortened, until, at the maximum depth, the actual working time in the caisson was reduced to two hours per day, divided into three shifts of 40 minutes each, the same men going in at intervals of four hours. During 25 days the work on Pier III., and during 28 days the work on Pier II., was carried on in over 100 ft. of water. The actual maximum depth at which the men worked was about 108 ft.

The concrete used was composed of crushed lime stone, sand and cement. The sand was dredged from the bottom of the Mississippi River and was of excellent quality. The cement used was manufactured near Louisville, Ky. In special portions of the work German Portland cement was used. The concrete was generally made in a machine mixer, the capacity of which was about 20 cu. yds. per hour. The mixer, together with a derrick and hoisting engine, were carried on a barge 90 ft. long, 30 ft. wide and 5½ ft. deep. A platform, large enough to handle three batches of concrete, was built on the barge about 5 ft. above the deck, and the mixer was placed under this platform. The cement and sand were first thoroughly mixed together, spread over the crushed rock, and shoveled, while dry, into the mixer, where the water was added. The mixer discharged the concrete directly into buckets, which were deliverd by the derrick where required. The concrete above the working chamber was generally gaged one barrel of cement to 7½ cu. ft. of sand and 13¾ cu. ft. of crushed rock. In the lower portion of the V-shaped walls, where some leakage existed, the proportion of crushed rock was reduced nearly one-half. The concrete used to fill the working chamber was generally mixed similarly to that used above, but the amount of crushed rock was reduced in all places difficult of access. The lowest 2 ft. of concrete was made with Portland cement, and the 6 ins. of filling under the shoulder of the cutting edge, the cross walls and the flat surface of the roof were Portland cement mortar, three parts of sand to one of cement; all other parts of the filling were Louisville cement concrete. The masonry of Pier III. is shown in Fig. 6. That of Pier II. is very similar, with the slight differences before mentioned. The cost of the two piers is given in the accompanying table:

Table Showing the Cost of Piers II. and III., Memphis Bridge.

	Pier II.			Pier. III.		
	Material.	Labor.	Total.	Material.	Labor	Total.
Launching-ways	$1,792	$1,824	$3.617	$1,885	$1.788	$3,673
Caisson	45,850	24,168	70,018	33,117	17.976	51,094
Concrete above chamber	10,528	3,847	14.376	7 393	2,448	9,842
Concrete in chamber	3,811	1,310	5,125	6,383	2,174	8,558
			$93,136			$73,167
Mattress	12,362	5.634	17,996	4,543	2,127	6.671
Anchoring caisson	4 619	2,087	6,707	7,557	3,778	11,336
Sinking caisson	17,215	50,826	68,042	19,432	59,534	78,967
Lighting pier	260	2,398	2,659	55	178	235
Insurance	552	......	553	394	......	395
Protecting foundation	......	......	......	562	101	663
Placing, sinking, etc	......	......	$95.957	......	......	$98,267
Total foundation		......	$189.094	......	......	$171,435
Masonry (4,197 cu. yds.)		......	108.669	......	......	124,442
Total cost	......	.. ..	$297,763	......	......	$295.877

Pier II + 4870 cu. yds. in Pier III

Tests made on the clay of the foundation beds for both piers showed, for the clay of Pier II., an average resistance to compression of 13,400 lbs. per sq ft., where entirely unsupported at the sides, and for that of Pier III. an average strength of 19,300 lbs. per sq. ft. The actual weights of Piers II. and III. were 10,410 lbs. and 9,934 lbs. per sq. ft., respectively; and after deducting buoyancy, friction, etc., the actual pressures on the foundation bed were 3,339 lbs. and 3,503 lbs. per sq. ft. respectively.

DETERMINING MINIMUM SECTION FOR OVERFALL MASONRY DAMS.

By Stockwell Bettes.

The following is offered as a solution of the problem: To find the best section for a masonry overfall dam, or the section that with any required degree of stability demands the least amount of material.

Let us, in the first place, consider a triangular section, ABD, Fig. 1, whose thickness is unity and specific gravity s. Let the water pressure against the upper edge of the section be represented by the triangle ABC. Let BD, the horizontal base, $= b$, $BE = nb$, $AF = h$, and $BF = x$.

Now, making the moment of pressure of the water about the point E equal to the moment of resistance of the section about the same point, we obtain the following equation:

$$h^2 + x^2 = b^2 (3n - 1) s + b (3n - s) s \qquad (1)$$

For the minimum value of b, we derive from this equation.

$$x = \frac{b}{2} (3n - s)$$

and by substituting this value of x in equation (1) and reducing, we obtain,

$$b = \frac{2h}{\sqrt{9n^2 + (3n - 2) 2s + s^2}}$$

and

$$x = \frac{h (3n - s)}{\sqrt{9n^2 + (3n - 2) 2s + s^2}}$$

From these equations it is seen that the values that are assumed for n and s wholly determine the section. The angle ABD will be equal to, less than, or greater than, a right angle, according as the assumed values of n and s make $3n - s$ equal to, greater than, or less than, 0. Within the limits of the values usually assumed for n and s the sectional area changes but little, and we shall assume hereafter that BA (Fig. 2) is vertical, or that $x — 0$. Putting this value of x into equation (1) reduces it to

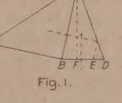

Fig. 1.

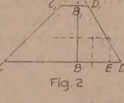

Fig. 2

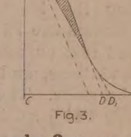

Fig. 3.

$$b = \pm \frac{h}{\sqrt{(3n - 1) s}} \qquad (2)$$

Now, if h is diminished by removing horizontal strips from the lower part of the section, the stability of the remainder is not affected; but if, on the contrary, we remove a piece from the top of the section, for example, to the line B_1D_1, while the stability along that line is unchanged as we pass below the line the stability is uniformly increased.

To retain in the section the condition of uniform stability the base must be decreased, and to find the value of b ensuing, we make the moment of pressure of $BB_1 C_1 C$ about the point F_1 Fig. 2, equal to the moment of resistance of $BB_1 D_1 D$ about the same point.

Let $B_1 C_1 = h_1$, $B_1 D_1 = b_1$,

and we shall have, after reducing,

$$\frac{(h - h_1)(h + 2h_1)}{(3n - 1) s} = b^2 + b b_1 + \frac{b_1^2}{3n - 1} \qquad (3)$$

By substituting in this equation the value of b_1 derived from equation (2), or

$$\frac{h_1}{\sqrt{(3\,n-1)\,s}}$$

we shall finally obtain the value of the base,

$$b = \frac{-h_1}{\sqrt{(3\,n-1)\,s}} \pm \frac{1}{2(3\,n-1)} \sqrt{\frac{4\,(h-h_1)\,(h+2\,h_1)\,(3\,n-1)}{s} + 3\,h_1^2\,(n+1)} \quad (4)$$

As an example, we may take the case of the Austin Dam (Fig. 3, Eng. News, July 11 and 14, 1891; April 9 and 18; Sept. 29; Nov. 10 and Dec. 22, 1892; Jan. 12, 26; Feb. 23; June 8 and 29, 1893). Here the dam is 60 ft. high, with, say, 17 ft. of water above its crest in the extreme cases. Assuming $n = 0.75$ and $s = 2.3$, $h = 77$ and $h_1 = 17$. With these values, we find from equations (2) and (4) for the top

$$b_1 = \frac{17}{\sqrt{1.25 \times 2.3}} = 10.00$$

and for the bottom $b = 44.21$. The dimensions of the dam are, at the top, 18 ft.; at the bottom, 40.5 ft. And if the section is curved at the bottom in the way that the dam is, there is a saving of 8½% in the sectional area and the stability of the proposed section is greater than that of the dam.

Other examples might be given in which the economy is more manifest. It is, however, not designed to criticise any work, but simply to suggest, what seems to me a better method than has heretofore been followed in fixing the section for an overfall dam.

THE PHOENIX IRON CO.'S 1,200-TON TESTING MACHINE.

In our issue of Jan. 10, 1891, we illustrated in detail the construction of the 1,200-ton hydraulic testing machine constructed by the Phoenix Iron Co. to meet the demands of their extensive business in testing full-sized members for bridges and other structures. While these drawings showed the construction and operation of the machine very completely, the accompanying engravings from photographs recently made are of interest as showing the general appearance of the most powerful machine for making general tension and compression tests in the world. Fig. 1 of these engravings gives a general view of the machine, and Fig. 2 is a view looking toward the cylinder end with the tail block in the foreground.

As seen by Fig. 1, there are two main girders, between which are the cylinder and the head and tail blocks with their accompanying mechanism for adjusting the length and absorbing the recoil. These girders are 78 ft. long over all and 51½ ins. deep and rest on compound plate girders bolted to the foundations, and to which they are braced by gusset brackets. The sectional area of one of these girders is 244½ sq. ins., and they will take in for testing an eyebar 50 ft. long c. to c. of pin holes.

The cylinder is 64.1 ins. in diameter with a 6-ft. stroke, and is bolted to the main girders with 80 turned steel bolts 2 ins. in diameter. The head block is fastened to four piston rods 8½ ins. in diameter, and the tail block has four pulling rods of the same dimensions. The stop pin securing the tail block to the main girders are 9½ ins. in diameter, two through each girder.

The machine is designed to work up to a duty of 2,160,000 lbs., requiring a pressure of 720 lbs. per sq. in. on the piston area; but it can with safety be worked at 800 lbs. pressure, which amounts to a load on the piston of 2,400,000 lbs. Steel has been used throughout in its construction, the girder work being done in the shops of the Phoenix Iron Works and the machine work by the Chester Foundry & Machine Co., of Chester, Pa.

The demurrage system of charges for freight car detention has been adopted by six New England railways, and after Jan. 1 there will be a minimum charge made of $1 per car for each day or fraction of a day if the car is not unloaded within 96 hours after placing. The general adoption of such a system is very desirable in order to reduce the unreasonable detentions which now prevail in car service, as noted in our issue of Jan. 24, 1891. The railways which have just adopted this system are the Boston & Albany R. R., Boston & Maine R. R., Concord & Montreal R. R., Fitchburg R. R., New York & New England R. R., and the New York, New Haven & Hartford R. R.

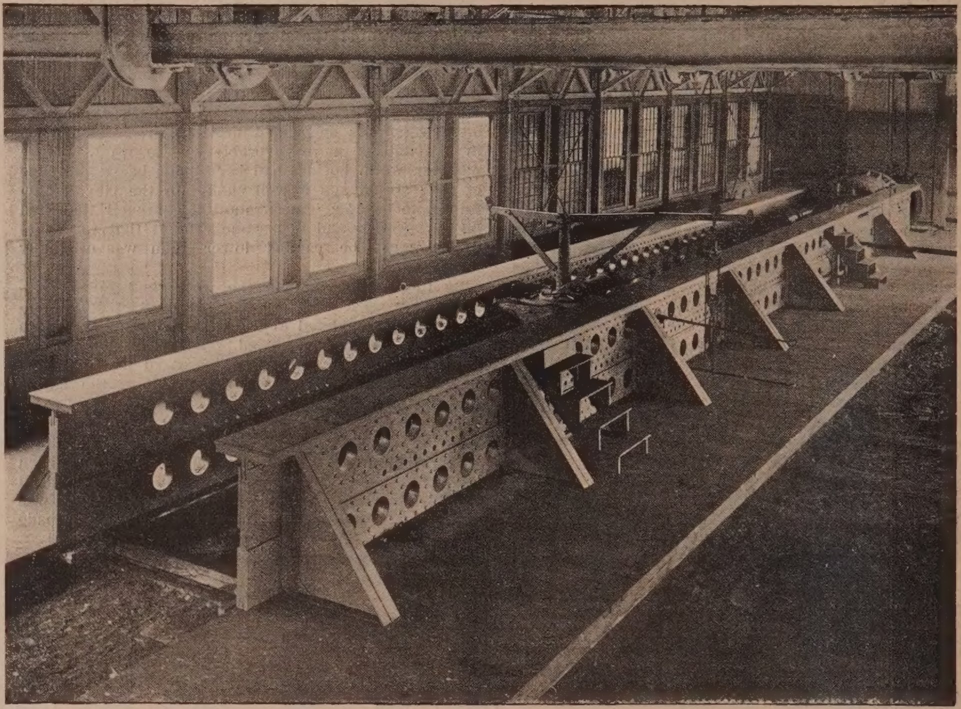

FIG. 1. GENERAL VIEW OF 1,200-TON HYDRAULIC TESTING MACHINE, PHŒNIX IRON CO., PHŒNIXVILLE, PA.

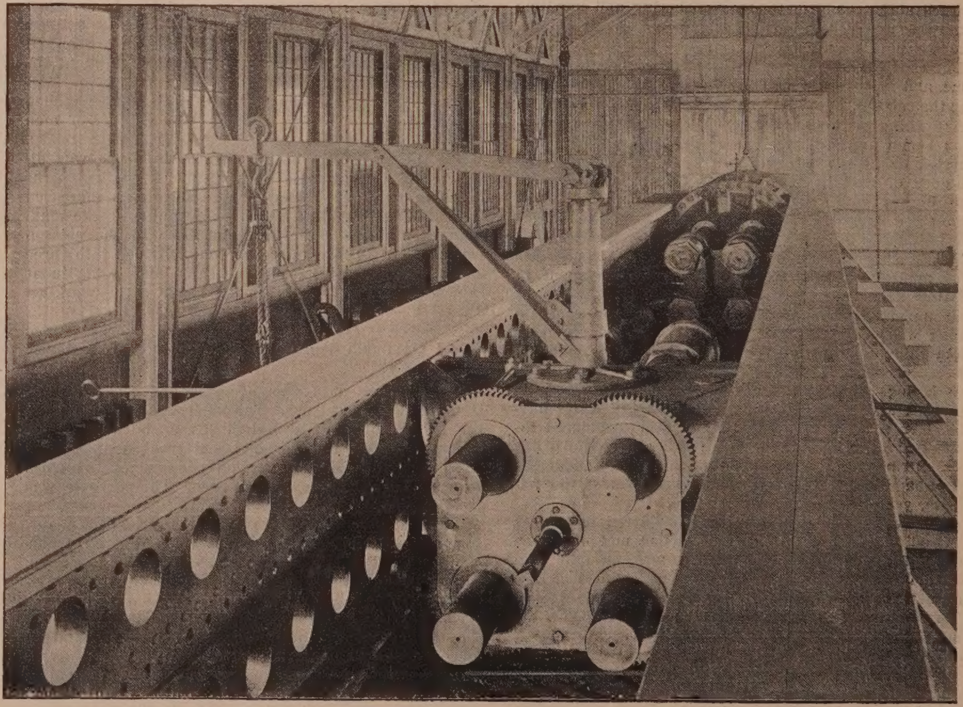

FIG. 2. VIEW OF 1,200-TON TESTING MACHINE; LOOKING TOWARD CYLINDER END.

The phonophore telegraph which is in use on several English railways enables them to send an extra independent message on the ordinary telegraph wire in either direction at the same time that telegrams are being sent by the ordinary telegraph. By its use also communication has been maintained under circumstances which rendered the ordinary telegraph altogether useless, as it has been found that when the ordinary telegraph would not work, on account of a breakage of the wire, the messages were sent by the phonophore, the currents by which it is worked jumping the gap of the break and thus kept up the communication, while the ordinary telegraph was dumb.

One of the three electric railways operated by overhead wires in the United Kingdom is on the island of Guernsey, and was operated originally by steam motors, but the electric system has been in operation since the spring of 1892. It is a single track line of standard gage, about three miles long, with three passing places, and a maximum grade of 2½%. Girder rails are laid through the town, and 40-lb. T-rails outside, the rails being bonded by strips of iron. The power house is situated at about the middle of the line and has a duplicate plant, consisting of two 25-HP. engines, two locomotive boilers and two Siemens dynamos. The dynamo in service is often worked at 50% above its normal capacity. The overhead wires are carried by arms projecting from iron tubular poles 25 ft. high, and the trolley arm is a steel tube. There are three four-wheel cars, seating 52 passengers each, and four cars on four-wheel trucks, seating 68 passengers each. The former have a motor on one axle, driving the other axle by a chain and sprocket wheels. The latter have spur gear running in oil. The speed of cars is from 5 to 12 miles per hour.

Passenger and freight car axles of Siemens-Martin steel for the Great Northern Ry., Ireland, are specified to stand a test of ten blows of a 2,240-lb. weight, falling 18 ft., the axle to be placed on bearings 3 ft. 6 ins. apart, c. to c., and turned over after each blow.

The results of crowding population is being investigated by the Public Health and Housing Committee of the London County Council. The rapid increase in value of business property is constantly making it necessary to provide house accommodations on cheaper land, and this is leading the committee to an exhaustive study of the means of transportation by railways, tramways, omnibuses and steamboats. From a health point of view the question was equally pressing, as is shown by the following mean death rate in different groups of districts of the metropolis in the seven years ending in 1891:

	Mean. death rate 1885-91.
Districts with a density of under 40 persons per acre	15.27
Do. from 40 to 80	19.04
Do. from 80 to 120	19.24
Do. from 120 to 160	22.60
Do. over 160	23.88
County of London, do. over 57	19.90

The expense of handling ore at the ports of the Lake Superior region has been lately much reduced by improved machinery. Whereas the cost was formerly 10 to 15 cts. per ton, at some of the docks ore is now lifted from the hold, carried back 350 ft. and dumped for from ¾ to 1½ cts. per ton, all expenses included. Two thousand tons of iron ore have been stocked in 17 hours with only 21 men working in the hold.

An electric light, with lens and mirror, has been advantageously used in shaft sinking at the Walkinshaw colliery, near Paisley, Scotland. This light, fixed at the top of the shaft, had an illuminating power of 4,000 to 5,000 c. p., and was operated by an Elwell-Parker continuous current, compound-wound machine of the equivalent of 2 HP. The shaft was circular, 13 ft. in diameter and 260 ft. deep, lined with brick. From the brilliancy of the light at the bottom it was believed that this light would have answered for a 1,200-ft. shaft. It could not, however, pierce the fog and smoke following a shot, and this was the most serious drawback.

The cable railway at Brixton and Streatham, in the south of London, is not approved of by the residents along the route, who have made a complaint to the Board of Trade. They claim that the noise is excessive, due to the granite block paving; that the removal of dirt from the conduit to the side of the road is a danger to health; that the vibration has caused the cracking of walls and ceilings of houses, and that the grip frequently fails. The road is operated under a one-year's license from the Board of Trade, whose inspecting officers will make an investigation before renewing the license, but it was pointed out in the answer to the complaint that the stone paving was a matter for the consideration of the local authorities.

PERSONALS.

Mr. O. L. Walcott, formerly State Commissioner of Railways and Telegraphs of Ohio, died at Warren, O., Dec. 9.

Mr. L. A. Washington has been appointed Superintendent of the Ohio Valley R. R., with offices at Henderson, Ky.

Mr. Allard D'Heure has been appointed Division Engineer of all Southern Pacific Ry. lines in Louisiana, with headquarters at Algiers, La.

Mr. Edward F. Luce has been appointed manager ofthe car department of the Wickes Refrigerator & Car Co., with offices in the Monadnock Block, Chicago.

Mr. M. Reilly has been engaged as Superintendent of Construction of the Wentworth Ave. sewers by Wilson & Jackson, the contractors, Times Building, Chicago.

Mr. A. B. Pullman, Second Vice-President of the Pullman Palace Car Co., and having charge of the construction department, died at Chicago, Dec. 18. He was born in 1828.

Mr. Charles Stein, Superintendent of Roadway and Buildings, of the Toledo, Ann Arbor & North Michigan Ry., has been appointed Superintendent, vice Mr. John B. Connors, resigned.

Mr. Geo. M. Jarvis has been appointed Division Engineer of the Galveston, Houston & San Antonio Ry., between San Antonio and El Paso, Tex., including the Eagle Pass branch, with headquarters at Del Rio, Tex.

Mr. C. A. Hammond, Secretary of the American Society of Railway Superintendents, has resigned his position as Superintendent of the Boston, Revere Beach & Lynn R. R., which position he has held since 1892. Mr. John A. Fenno, treasurer of the road, will perform the duties of superintendent and treasurer.

Mr. Walter Aiken, of Franklin Falls, N. H., President of the Mt. Washington R. R., died recently at Havre de Grace, Md. He was chiefly instrumental in carrying out the project of a rack railway up Mt. Washington, which was a conception of his father, and had been Manager of the road since 1869. He was an inventor of some reputation and took out many patents on knitting machinery, being connected with some large mills in New Hampshire.

NEW PUBLICATIONS.

THE MANUFACTURERS OF THE UNITED STATES. —A Classified and Complete Reference Book for Buyers and Sellers for Domestic and Foreign Trade. New York: Manufacturers' Publishing Co. 4to; pp. 2,055; $10.

This ponderous volume is of particular value in commercial circles, as it contains lists of articles (all articles manufactured in this country), with their manufacturers, alphabetically arranged. The work has been compiled from blanks sent out to the various manufacturers, and forms an important work of reference. It is, of course, not free from omissions; for instance, under "Tramways, Overhead," no mention is made of the California Wire Works, or of Badgley & Co. (Eng. News, Nov. 9), but it would obviously be impossible to ensure absolute completeness and accuracy in a publication of such magnitude, and, while the errors are to be regretted, they probably detract but little from the practical value of the book.

COLORADO IRRIGATION LAWS.—Published by the State Engineer at Denver. Paper; pp. 197.

This compilation of the irrigation laws of Colorado is accompanied by instructions to the superintendents and commissioners in charge of the distribution of water and will be welcomed by all who have occasion to study irrigation law.

GEOLOGY OF THE WYOMING EXPERIMENT FARMS AND MINERAL RESOURCES OF THE STATE.—Bulletin No. 14 of the Wyoming Experiment Station, Agricultural College Department, University of Wyoming. By the Geologist. Paper; pp. 211.

The object of the first part of this report is to determine various formations entering into the soil compositions of the experimental farms. The mineral resources are discussed both by counties and by kinds of minerals, and some statistics of output are given. Mr. W. C. Knight is geologist of the Laramie station.

STANDARDS AND RECOMMENDED PRACTICE OF THE MASTER CAR BUILDERS' ASSOCIATION. —John W. Cloud, Secy., Rookery Building, Chicago; pamph.; pp. 15.

In accordance with the action taken by the last annual convention of this Association, all the standards and "recommended practice" now existing have been republished in a new and corrected form. The drawings showing the standards are printed on 13 lithographed sheets, each 30 × 38 ins., which are sold at 25 cts. each. The sheets are of thin paper, and blueprints can be taken directly from them. Most of the drawings are made full size, which, perhaps, corresponds to the general practice in car shops. The big, clumsy blueprints, made from such large sheets, however, are really awkward for shop use, compared with a reduced size drawing, as small as is consistent with clearness, mounted on cardboard. We can well afford to ignore the needlessly large size of the drawings, however, in view of the fact that the standards of the Association are now presented in systematic and correct shape.

MANUAL OF PRACTICAL ASSAYING. By H. Van F. Furman, E. M., M. Am. Inst. M. E. New York: John Wiley & Sons; cloth; 8vo; pp. 390; $3.

The author of this book is a working chemist of experience, having been connected at different times with the Germania Lead Works, of Salt Lake City, The Rio Grande Smelting Works, of Socorro, N. M., and the Globe Smelting Co., of Denver. The book is really broader than its title may indicate to the general reader, for the author takes up not only the work on the precious metals, which chiefly engage the assay offices in the West, but the analses of ores of iron, aluminum, copper, zinc, and in fact all the commercial metals. The book is intended for laboratory use by the working chemist, and the author confines himself to practical methods and processes, giving little space to abstract theory.

MONTANA IRRIGATION CONVENTION.—Report of Proceedings of the Second Convention, held at Helena, Mont., Feb. 9 and 10, 1893, with Reports of the State of Irrigation in Several Counties. S. B. Robbins, Secretary. Pamph.; pp. 56.

This report gives an idea of the progress of irrigation in Montana and contains some other information of general interest to irrigators.

SURVEYORS' TABLES.—Being the Tables from the "Manual of Land Surveying." F. Hodgman, Climax, Mich. 12mo; pp. 106; $1.

This is a handy little book containing 16 tables of logarithms, sines and cosines, tangents and cotangents, logarithmic sines, traverse tables, secants, etc., from Mr. Hodgman's "Manual of Land Surveying."

TRADE PUBLICATIONS.

GOOD ROADS AND HOW TO MAKE THEM.—American Road Machine Co., Kennett Square, Pa. 8vo; pp. 48; illustrated.

This pamphlet gives some practical information on methods of road construction and maintenance, and describes and illustrates the various machines manufactured by this company, including grading machines, scrapers, plows, road rollers, dump carts and rock crushers, some of which have already been described in our columns (Eng. News, Nov. 30).

SOCIETY PROCEEDINGS.

CIVIL ENGINEERS' CLUB OF CLEVELAND.—At the meeting on Dec. 12, Mr. L. E. Chapin, of Canton, O., read a paper on "Sewage Disposal at Canton, O."

IOWA SOCIETY OF CIVIL ENGINEERS AND SURVEYORS.—The sixth annual meeting will be held in Cedar Rapids, Ia., commencing Jan. 17, 1894.
Seth Dean, Secy.

TECHNICAL SOCIETY OF THE PACIFIC COAST. —The next regular meeting will be held Jan. 5, 1894, in the rooms of the society, 819 Market St. Mr. Chas. F. Hoffman will read a paper entitled "Notes on the Golden River Drift Mine, Better Known as the Red Point Mine."
Otto von Geldern, Secy.

ENGINEERS' CLUB OF ST. LOUIS.—At the meeting on Dec. 20 the result of the election of officers was announced as follows: President, B. L. Crosby; Vice-President, S. B. Russell; Secretary, Wm. H. Bryan; Treasurer, Chas. W. Melcher; Librarian, T. L. Condron; Directors, Edward Flad and Robert Moore; Members Board of Managers, J. B. Johnson and S. B. Russell. After the result had been announced Mr. Moore called Mr. Crosby to the chair. Mr. Crosby thanked the club and called on the retiring president for the annual address. Mr. Moore reviewed the work in engineering for the past year.
Arthur Thacher, Secy.

COMING TECHNICAL MEETINGS.

CIVIL ENGINEERS' SOCIETY OF ST. PAUL.
Jan. 1. Secy., C. L. Annan, City Engineer's Office.
ENGINEERS' SOCIETY OF PHŒNIXVILLE.
Jan. 2. Secy., W. Halliburton.
INDIANA ENGINEERING SOCIETY.
Jan. 2, 3 4. Annual meeting at Indianapolis. Secy., W P. Carmichael, Williamsport, Ind.
MICHIGAN ENGINEERING SOCIETY.
Jan. 2, 3, 4. Annual meeting at Jackson. Secy., F. Hodgman, Climax, Mich.
WESTERN SOCIETY OF ENGINEERS.
Jan. 3. Secy., Jno. W. Weston, 51 Lakeside Bldg., Chicago.
AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 3. Annual meeting Jan. 17, 18. Secy., F. Collingwood, 127 East 23d St., New York.
ENGINEERS' CLUB OF ST. LOUIS.
Jan. 3. Secy., Arthur Thacher, Odd Fellows' Building.
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Jan. 4. Secy., C. H. McLeod, Montreal, P. Q.
ENGINEERS' CLUB OF MINNEAPOLIS.
Jan. 4. Secy., E. Nexsen, 504 Kasota Block.
ASSOCIATION OF CIVIL ENGINEERS OF DALLAS.
Jan. 5. Secy., E. K. Smoot, 808 Commerce St.
TECHNICAL SOCIETY OF THE PACIFIC COAST.
Jan. 5. Secy., O. Von Geldern, 719 Market St., San Francisco.
ENGINEERS' CLUB OF PHILADELPHIA.
Jan. 6. Secy., L. F. Rondinella, 1122 Girard St.
SWEDISH ENGINEERS' CLUB.
Jan. 6. Secy., P. Valentine. At 231 Union St., Brooklyn, and 646 North 10th St., Philadelphia. At 180 La Salle St., Chicago. Secy., John Ericson.
ENGINEERS' CLUB OF KANSAS CITY.
Jan. 8. Secy., Waterman Stone, Baird Building.
WISCONSIN POLYTECHNIC SOCIETY.
Jan. 8. Secy., M F. Schinke, City Hall.
CIVIL ENGINEERS' CLUB OF CLEVELAND.
Jan. 9. Secy., F. C. Osborn, Case Library Bldg.
NORTHWEST RAILROAD CLUB.
Jan. 9. Secy., W. D. Crosman. Ryan Hotel, St. Paul.
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DENVER SOCIETY OF CIVIL ENGINEERS.
Jan. 9. Secy., F. E. King, Jacobson Block.
ENGINEERING ASSOCIATION OF THE SOUTH.
Jan. 9. Secy., Hunter McDonald, Nashville, Tenn.
CIVIL ENGINEERS' ASSOCIATION OF KANSAS.
Jan. 10. Wichita, Kan.
NEW ENGLAND RAILROAD CLUB.
Jan. 10. Secy. F. M. Curtis, P. O. Box 1576, Boston.
ENGINEERS' AND ARCHITECTS' CLUB OF LOUISVILLE.
Jan. 11. Secy., F. W. Mowbray, Norton Building.
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Jan. 12. Secy., D. W. Meeker, St. Paul.
MONTANA SOCIETY OF CIVIL ENGINEERS.
Jan. 13. Secy., G. O. Foss, Helena.
COLUMBIAN ENGINEERING SOCIETY.
Jan. 16. Secy., F. W. Hart, Washington, D. C.
ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.
Jan. 16. Secy., R. H. Clark, Pittsburg.
WESTERN RAILWAY CLUB.
Jan. 16. Secy., Clement F. Street, Chicago.
ASSOCIATION OF ENGINEERS OF VIRGINIA.
Jan. 17. Secy., L. J. Carmalt, Roanoke, Va.
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Jan. 18 Secy., J. F. Wilson, 24 W. 4th St.
NEW YORK RAILROAD CLUB.
Jan. 18. Annual meeting. Secy., John A. Hill, Temple Court.
SCANDINAVIAN ENGINEERING SOCIETY OF CHICAGO.
Jan. 18. Secy., Allen Strale, 100 Washington St.
SOUTHERN AND SOUTHWESTERN RAILWAY CLUB.
Jan. 18. Secy., S. A. Charplot, Macon, Ga.
TACOMA SOCIETY OF ENGINEERS AND ARCHITECTS.
Jan. 19. 201 Washington Building.
CENTRAL RAILWAY CLUB.
Jan. 24. Secy., S. W. Spear, Buffalo, N. Y.
BOSTON SOCIETY OF CIVIL ENGINEERS.
Jan. 24. Secy., S. E. Tinkham, 36 Broomfield St.

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AND

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ADVERTISING RATES: 20 cents per line agate measure. Schedule sent on request. Changes of advertisements must be in hand on Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements, not later than Wednesday noon. The last pages go to press early on Thursday. We shall be obliged if subscribers who fail to receive their papers promptly will notify us without delay.

At the request of one of the leading engineering schools, which does not require its graduates to send in their theses until Sept. 20, the time for receiving theses in competition for the four prizes which we offer is extended until Oct. 1. The examination of such theses as have been received, however, will begin Sept. 1, and it is desired that, so far as possible, they may be sent in before that date. The conditions for the competition were published in our issue of Dec. 14.

The proper form for an annual municipal report is a subject worthy of careful consideration by every official whose duty it is to make one. Its first object should be to present facts and figures relating to the operations and conditions of the department or business concerned, which will be of present and future value to the municipality. The second object should be the setting forth of information of use to officials and engineers in other cities, thereby making possible that comparison of methods and results which is so essential to those who keep up with the times. Generally speaking, if a report is made of the greatest possible local value, little care need be exercised to increase its usefulness to outsiders. Both the American and New England Water-Works Associations formulated, some years ago, a uniform system for the statistical part of water-works reports. That suggested by the New England association seems to have been most widely adopted, both in and out of New England, although the other form is a good one. The officials of the New England association are now making an effort to induce their members, and all other officials as well, to make use of this form, and now have ready for distribution to all who will apply for them, regardless of locality, copies of the form. Either the Senior Editor of the Journal of the New England Water-Works Association, Mr. Dexter Brackett, M. Am. Soc. C. E., City Hall, Boston, Mass., or the Secretary, Mr. R. C. P. Coggeshall, New Bedford, Mass., may be addressed.

An amusing interview with a person whom the reporter dignified with the title "expert engineer" was recently published in one of our Pittsburg exchanges. The alleged expert was interviewed with reference to the plans for securing a purer water supply for the city of Allegheny; and he strenuously opposed the plan for filtering the supply which has been proposed by Mr. Julian Kennedy, M. Am. Inst. M. E. "Filtration," said this expert, "is impracticable. It takes a chemist 24 hours and at considerable cost to make water chemically pure." In place of filtration he would "construct a vitrified brick and cement conduit below the bed of the Allegheny River, and between the high and low water mark, extending up the river some distance. No filters will do the work of such a conduit. The water runs over the brick and cement and is thoroughly oxygenized. The impurities settle to the bottom and it could be arranged to have the conduit cleared when necessary."

By such means a supply might be obtained, our expert states, for both Pittsburg and Allegheny. The conduit might be built five miles each year, shifting the intake from year to year, until it reached 100 miles up the river. This would cost, we are told, about half as much as for filtration, and, surprising to state, "this method of securing good water is used by New York, London and Paris."

Unfortunately for the argument, the water supply of London, except that from deep wells, is all filtered, and has been for nearly 40 years, while the long conduits of New York and Paris are designed to reach to and convey water which needs no purification. Go far enough up the Allegheny River and probably a pure water supply could be secured, but what would be its cost as compared with filtration?

It is an interesting fact that, until within a week, the two oldest living graduates of the West Point Military Academy were both civil engineers very prominent in the civil practice of their profession and both were Honorary Members of the American Society of Civil Engineers. The oldest of these two distinguished men, Mr. William Clark Young, was born Nov. 25, 1799, and died on Dec. 22 at his residence in New York, aged 94 years. The other is Gen. George S. Greene, of Morristown, N. J., born in 1801, and who still enjoys a vigorous old age. As to precedence in rank, Mr. Young graduated from the Military Academy on July 1, 1822, and General Greene graduated one year later, on July 1, 1823, both as Second Lieutenants of Artillery. Mr. Young resigned from the army in 1826 and almost immediately afterward became engineer for the State of New York in the survey of the West Stockbridge & Albany railway. He was later professionally engaged on the Baltimore & Ohio R. R.; resident engineer on the Saratoga & Schenectady R. R., in 1831-33, and chief engineer of the Utica & Schenectady, from 1833 to 1849, and chief engineer of the Hudson River R. R. from 1848 to 1851 and was president of the latter corporation until 1852. He was also president of the Panama Railway Co. in 1852-3. His last recorded service was as superintendent of the Western Division of the New York Central R. R. and branches. Mr. Young came of a long-lived stock; his great-grandfather lived to the age of 107, his grandfather was 94 years old when he died and his father was 80 years old. He was an intimate friend of General Greene, who is now the oldest living graduate from West Point.

Maj.-Gen. George S. Greene is much better known to the present generation of civil engineers, for he is still with them on all special occasions; full of interest in all that interests them and carrying his 92 honorable years with the vigor and grace of one his junior by a generation. Mr. Greene resigned from the army in 1836 and at once commenced the practice of a civil engineer on railway work in Massachusetts, North Carolina, Tennessee, Kentucky and Maryland. From 1847 to 1852 he was chief engineer of the Portland & Kennebec R. R.; he was engineer of the Providence & Bristol Ry. in 1852-56, and engineer-in-charge of the Croton water-works extension and the Croton reservoir, in Central Park, from 1860 to 1862. He resigned a lucrative practice on Jan. 18, 1862, and again actively resumed his military career as Colonel of the 60th N. Y. Volunteers. He was made a Brig.-General on April 28, 1862, and participated in many hard-fought battles of the Civil War; was severely wounded and finally left the service in 1866 as a Brt. Major-General of Volunteers. General Greene at once returned as engineer of the Croton Water-Works Extension and remained in the service of the city of New York until 1871. He was later engineer of the proposed Central Underground Railway for New York, of 1871-72, and chief engineer of public works, in Washington, D. C., in devising a new sewerage system at the same time. He was then in active consulting practice on many important public works and commissions until about 1877, when he practically retired.

The career of these two men has been similar in many respects. Both entered the Military Academy at nearly the same time and both retired from the army after a comparatively brief service and at once commenced the practice of civil engineering at a time when engineers were few in this country, and thus both took rank as pioneers in the new profession. They attained about equal prominence as engineers, and as intimate friends for many years they, until very recently, shared the distinguished honor of being the two oldest living graduates from West Point. General Greene added to his record and testified to the natural vigor of his constitution by long and honorable service in the late Civil War, having entered the army after he had passed his 60th birthday, at an age generally and properly assumed as unfitting a man for the toil and dangers of a soldier's life. After four years spent in active service he again resumed the practice of his profession and he was actively engaged therein until he was over 76 years of age.

The nearest approach to the record of General Greene that we can find is the almost equally remarkable one, except as to long life, of the late Gen. Daniel Tyler, of Connecticut, who was graduated from West Point on July 1, 1819; resigned in 1834 and became a prominent civil and mining engineer and was president and engineer of the Schuylkill & Susquehanna R. R. in 1861. Like General Greene, and at about the same age, he entered the service of the United States, on April 23, 1861, as Colonel of the 1st Connecticut Volunteers, and was made a Brig.-General in May, 1861. He was in more or less active service until April, 1864, when he resigned. General Tyler was born Jan. 7, 1799, and in his civil life was very prominent in the development of the iron interests of Pennsylvania and Alabama, and in 1835 he erected the first coke, hot-blast furnace built in America. He was also largely interested in successfully reorganizing railway and other corporate properties. He died in New York city in 1882.

A new illustration of the way in which the engineering work of the Boston & Albany R. R. is conducted has been furnished this week by the sudden destruction by ice (on Christmas day) of the temporary trestle which took the place of the now famous Chester Bridge. This bridge fell on Aug. 31 last, under circumstances of deep discredit to a long line of officials and contractors of the company, as shown in our issues of Sept. 7 and following. The bridge was a small one, consisting of two 110-ft. spans. How does it happen that almost four months after the fall of this structure there is still only a temporary trestle across this often turbulent stream? The stone piers were left intact. There was nothing to do but to re-erect the ironwork, which a dozen different shops could have furnished and erected, if necessary, in two to four weeks. What may be the capacity of the shops which have so peculiar a monopoly both of bridge construction and of bridge inspection on the Boston & Albany we do not know, but surely they also were equal to doing this work in a month or two, while it required no great foresight to foresee even in August that along about Christmas time in Massachusetts there is often some formation of ice which may do harm to a temporary trestle in the rapid current of a good sized river; and that if so, several days of expensive delay to traffic will be very likely to ensue.

There are some references in the press dispatches to the narrow escape of a train by good luck in being three minutes late which also have a peculiar look, but possibly this is only an effort of the reporter's imagination. It can hardly be that such a structure over a roaring river filled with ice was not at least closely watched.

A terrible and perhaps needed evidence of the danger of taking too many chances in erecting long bridge spans is afforded by the fall of the two 546½-ft. spans of the Louisville & Jeffersonville Bridge, all the circumstances in connection with which are fully reported in another part of this issue. It is always easy enough to be wise after the event, and many examples of such wisdom have cropped up regarding this accident in the last few days, but a certain proportion of such accidents must of course be expected. This certainly does not excuse any neglect to use every reasonable precaution against accidents. Whether there was such neglect in this particular case we leave our readers to judge for themselves from the evidence which is presented elsewhere. In regard to the causes contributing to the collapse of the falseworks of the first span there does not seem to be much reasonable uncertainty. The wind pressure on the top-heavy and unstable traveler overbalanced it, throwing nearly its whole weight of some 90 or 100 tons onto one corner; and the falseworks, already weak longitudinally, and perhaps further weakened by scour of the river bed, crushed down underneath the traveler. The destruction of the two or three bents under the traveler, of course, left a gap in the falseworks, toward which the remaining bents appear to have fallen like a row of bricks, twisting upstream in the fall. There seems no necessity to go further than this for an explanation of the collapse of the first span. It is generally understood that falseworks for bridge spans depend largely for their longitudinal stiffness upon the piers at each end; in other words, they are wedged in between the piers as it were, and the fall of any part is very likely to result in the collapse of the adjoining parts. This practice is not a question of good or bad engineering design, it is merely a question as to whether the danger from such accidents and their consequences is small enough to make it worth while to take the chances that no accident will happen. For this reason the accident which we describe may have a salutary effect in inducing greater care in the bracing of falseworks which may help to compensate for the appalling loss of life.

As a matter of engineering interest the fall of the first span, with all its record of fatalities, is quite overbalanced by the second accident, the fall of a span which had been erected for nearly a month, from beneath which all the falsework had been removed, and which, it is of interest to note, was the longest pin-connected truss span ever erected, so far as we can find. All accounts agree that the fall of this second span was in no way caused by the fall of the first.

The cause of the fall of the second span is assigned by the contractor to the force of the wind. In other words, a 550-ft. truss span with all its members complete, and with its joint connections so secured as to have at least half or two-thirds their full strength, was lifted bodily from its piers and dropped into the river. If this were a correct theory of the disaster, the confidence of engineers in the safety of existing bridge structures of even the best class might well be shaken. But even apart from contradictory evidence, the calculations, which many of our readers will doubtless at once make, seem to render this theory almost or quite untenable. The surfaces exposed to wind pressure on which a lifting force could be exerted were small. The floor was open and unfinished, and practically the only surfaces against which wind force could act were the chords, the floor beams and the lateral and transverse bracing. The total weight of the truss was in round numbers 2,000,000 lbs. Had a solid floor extended from pier to pier the full width between the trusses, exposing a surface of $30 \times 550 = 16{,}500$ sq. ft., it would have required a wind pressure vertically upward of $2{,}000{,}000 \div 16{,}500 = 122$ lbs. per sq. ft. to have lifted the great truss from its seat. It is needless to say that no such pressure could have existed even had such a surface existed for it to act upon.

It seems to us that the theory of the disaster advanced by Mr. Edwin Thacher in another column is a plausible one and is as likely to be the correct one as any. The splice joint near the middle of the end post was connected only by temporary bolts. This joint is supported vertically, but it is practically unsupported transversely. It was thus in no condition to resist a great bending moment due to heavy wind pressure. It moreover, appears that the bottom lateral bracing had not been put in place in the two end panels of the span. If this is true, it was manifestly impossible for any of the wind pressure on the floor system and lower half of the truss to reach the pier except by passing up the diagonal at the intermediate vertical post and down the lower half of the end post. That is, the bending moment was perhaps doubled at this joint over what it was normally intended to carry, and in its imperfectly fastened condition it failed. Of course failure at this point meant the fall of the entire span.

This second wreck was by great good fortune attended by no loss of life; but the property loss involved is such that every engineer in charge of bridge erection will not fail to take note of its circumstances and add something to his caution in handling such work. Summed up in fewest words, the moral appears to be, never trust a bolted joint any longer than is necessary to put a riveted one in its place; and as soon as a structure is erected, lose no time in placing and securing all its wind bracing.

THE BOSTON SUBWAY.

It now appears to be definitely assured that an entirely new departure in the way of city transit is to be tried in Boston, and under highly favorable auspices for its perfect success if the plan admits of it. This plan is to subway Tremont St., substantially as suggested in our issue of March 16, from which we quote the following to show exactly what the proposition is:

> The permanent remedy is simple and quite inexpensive. It is, as we see it, to subway both Tremont St. and Washington St., from curb to curb, through all the more crowded district (not over one-half mile long), extending the subways from time to time as the crowded district enlarges. The conditions for such subways are all remarkably favorable in five respects, which were all quite unfavorable in New York: (1) There are no sewers or water pipes of a size to offer serious difficulty in either street; (2) there is no danger of any trouble from water; (3) there is no quicksandy or otherwise treacherous or unstable material at any point; (4) there are very few high or heavy buildings on either route; (5) there are no vaults extending beyond the curb line, on Tremont St. at least, which is the line most urgently needed.
>
> Under these conditions the subways can easily be built, in the best manner and lined with glazed brick, for $2,000,000 per mile or thereabouts; while a subway half a mile long on Tremont St. alone, giving ample room for five tracks, will remedy all immediate troubles. At some future day a Washington St. subway and a half-mile tunnel under Beacon Hill to give access from the west, costing perhaps $300,000, would also be needed, and of course would be convenient even now.
>
> The advantage of such a subway is not alone that it doubles the width of the street at vastly less expense than an equal surface widening, but even more that it segregates the traffic, putting the electric car service by itself and leaving the ordinary street traffic to itself, leaving perhaps a few street cars still to run upon the surface to serve better local convenience. The total depression need not be great; hardly more than 14 ft.; 12 ft. for the cars and 2 ft. for the iron and asphalt roof above it. The climb up and down stairs of this height is not burdensome; for elevated lines it has to be much higher, and for the proposed Common terminus nearly twice as high.
>
> As compared with elevated lines, instead of greatly injuring two floors of the abutting buildings, it leaves those which exist uninjured, and adds a new and almost equally valuable ground floor below the old one. Landings (and practically a continuous sidewalk) can be secured at nominal cost from the self-interest of owners.
>
> The only apparent objections to such a scheme are: (1) That there are no direct precedents for such a subway, while there are many for elevated railways, and (2) that the public have a prejudice against subways. But granting that there are no precedents, what is the function of a wealthy and highly civilized city but to create precedents suited to its needs and conditions, instead of following unsuitable ones like sheep? But as a matter of fact, there is now a precedent for the probable conditions of such a subway in the subcellar lunching room of the Cafe Savarin, in this city, which is wholly below, and mostly under the street, wholly dependent on artificial light and ventilation, and yet one of the most attractive, expensive and crowded lunchrooms in town. As for the public dislike of subways, in so far as it is real and based on reason (which is not far), it is based upon the precedent of the London subway lines, which are discouraging to capitalists because they hardly pay, and offensive to the public because of bad air. But the air is bad only because steam locomotives are used in them, and they hardly pay only because they do not run where many of the public want to go. A similar construction used by electric motors only and running under the heart of London, would be a gold mine to its owners, and, if built as attractively as it might be at trifling cost, the most popular route of travel in the city.

The essential condition of the success of such a subway will be seen to be electric propulsion, at least within the subway, and preferably also outside of it. It being a fact that all the difficulties in Boston are confined to a very small area, and that outside of this area the distances traveled are so small as to make the speed of electric street cars ample for all reasonable requirements, an entirely different solution of the transit problem is indicated for Boston from what would be adequate for New York or other cities of great distances and vast population. Still, now that either electric or cable cars are coming in and horse and steam cars going out, entirely different conditions exist in all cities from what have had to be met heretofore. and the field for the profitable use of subways immediately below the street surface is enormously extended. We shall be greatly surprised, therefore, if the Tremont St. subway does not prove a more important, decisive and revolutionary precedent in respect to the transit methods of many cities even than the New York elevated lines, especially abroad, where such a public nuisance as elevated steam railways in crowded districts is never likely to be tolerated at all. If so, the Boston precedent will be a very important one, and will be watched by engineers throughout the world with great interest.

It is evident that the subway scheme in any form is utterly inapplicable to either horse or steam transit, on account of the vitiating effect of animals or steam engines on the atmosphere. The London steam subways and the Fourth Ave. street car tunnel in New York show what nuisances they become when thus contaminated, even with the utmost care in keeping them as wholesome as possible. As electric transit is a thing of yesterday, it need excite no surprise that the Tremont St. subway will be the first of its kind in the world. Such a scheme was until very lately a practical impossibility for any city, and since it has become possible there has been no city having a rapid transit problem pressing for immediate adoption to which the subway scheme offered so easy and so perfect a solution as it does to Boston. How perfect it is may not be realized by the citizens generally until after the event; but unless some grievous error is made in details, which it would be superfluous to anticipate, the result will be so satisfactory as to insure the speedy riddling of the crowded district with four or five subways, and Boston will then, in our judgment, have the first entirely satisfactory system of local transit which any city in the world has enjoyed. That the example is likely to be very extensively followed is evident from the simple fact that such a subway is at least some convenience to all, while it threatens no one with even the shadow of such injuries as create active opposition to surface or elevated lines. Therefore, after the precedent is once set and it is no longer possible to plead "the general issue" against them, that they are an untried novelty, they are likely to multiply with great rapidity, and it is risking little to predict that within a few years after the first one has been built they will be in extensive use, and will eventually exceed the total mileage of elevated railway, which is likely thereafter to cease to grow. This, we think, is evident by considering how the several classes of a city community are affected.

The taxpayer as such has no reason to complain, because the cost is comparatively small and the interest on most or all of it is collected from the street railways using the subway in the form of rental.

These street railway companies themselves may complain and oppose at first on general principles, but after they have once had a taste of the benefit to them from such subways, they should be the last of all to complain when the subway is built to fill a real need, as is evidenced in a measure by the fact that the creator and ex-president of the great West End Railway Co., which controls all of Boston's city transit, Mr. H. M. Whitney, has been from the first heartily in favor of the Tremont St. subway, even if built at his own company's sole cost. The present attitude of the company we do not know, but the public expectation is indicated by the fact that some claim it to be "a West End scheme." Few people realize what an enormous loss is enforced on surface railways in crowded streets by the slow speed involved, in the double form of increased expense and decreased receipts. In comparison with these losses the cost of rental, which may be from $50,000 to $100,000 per mile, is a trifle, provided this expense is restricted to the streets which are really overcrowded.

The patrons of the street cars are very much benefited, provided the cars and subways are well lighted. In this electric era it is easy to insure this, especially if the whole interior of the subway be nearly white. The Boston cars are now all brilliantly lighted by electricity. The saving in time and exposure to bad weather will be considerable to every passenger.

The abutting owners are the most benefited of all. As compared with an elevated line they neither gain nor lose in respect to the travel carried past their premises, but they save whatever injury is done to their frontage by an elevated line (which is always something even if overbalanced by benefits) and they gain what is in effect a new shop front below the surface level, which in many cases may be almost as valuable as their existing front.

The travelers by foot through the city gain a new sidewalk, always dry and shady, warm in winter, cool in summer. It is likely to be much more largely used than the surface sidewalks. In a deep tunnel the difference of temperature might be so great as to threaten injury to health, but in a subway separated from the street only by a thin roof this difference cannot be so great as to be injurious to health, while it will materially add to comfort. If, however, any one prefers to keep to the surface he will be able to do so, and cross the streets at will with safety, which he cannot now. A large part of the agitation in Boston has sprung from the fact that ladies, children, the infirm and the absent-minded run a serious risk in trying to dodge the electric cars on crossing streets.

All drivers of drays and carriages will gain the material advantage of being no longer interfered with by street cars. These have become so thick in the narrow streets of Boston as practically to destroy the old carriage travel from the suburbs, which used to be a large element in the retail trade of the city. While one subway may not restore this, it will make what still exists safer, and the general adoption of the subway system for the whole central district will certainly do so.

It follows from these facts that the construction of such a subway is at least an important and promising experiment. It remains only to summarize the past course of opinion and action on the subject up to the present time.

About three years ago, after many years of general agitation, a rapid transit commission of eight members was created by the legislature, which reported in April, 1891, in favor of a four-mile elevated belt railway at a cost of $8,500,000 and sundry street widenings at a cost of $12,000,000. We reviewed its report at some length in our issue of March 16, 1893. No serious effort has ever been made to carry out the plan thus recommended, for reasons made clear in our review.

Finding this to be the case, Mayor Matthews, who had acted as chairman of this commission, worked up and presented a different plan of his own for an elevated railway line, which we reviewed in detail in our issue of March 23, 1893. It was an improvement on the commission's plan and found more favor, but, for reasons shown more fully in our review, would not have been likely to be a financial or popular success if built. The legislature thought well enough of it to submit it to a vote of the people, by whom it was rejected in the elections of last month. It involved an expenditure of some $12,000,000. With unusual and most commendable public spirit, the mayor has accepted this popular verdict in good part, as decisive for the present at least, and is now, we have reason to believe, doing his best to make the subway project an entire success; a fact the more unusual and notable because he was unquestionably in a position to have killed or retarded the subway project without taking any active part against it, but simply by silent neglect, had he chosen to do so.

In the meantime while this public action was going on, the West End Railway Co., hard pressed to manage its surface railway traffic, and perhaps foreseeing that the elevated lines were little likely to be built at such large expense, developed a plan of their own for "making a colander of the Common," as its opponents described it, by running a street car tunnel under it with frequent perforations upward "for ventilation and light." Included in this scheme (shown by us in full March 16, 1893) was a plan for an enormous sunken terminus in the very heart of the Common (and hence at a considerable distance from the business centers) barely missing the sacred Frog Pond. It was an ill-conceived and unwise scheme from every point of view, but most of all from that of the company's own interest, as in addition to injuring the Common greatly it would have been enormously expensive and would have seriously discouraged traffic by the remoteness, darkness and deepness of its terminus. It immediately and justly excited intense popular opposition, and was somewhat unfairly regarded as an instance of corporate greed. This it hardly was, as the company offered to build it at its own expense, at a probable cost of $4,000,000 at least, and it necessarily involved a much greater sacrifice of its own than of the public interest. The company did not at first realize this fact, it is true, but as it gradually began to dawn on its managers they dropped the whole project with amusing haste, and with inward thankfulness of heart, we may be sure, at the public opposition.

The opposition was chiefly voiced by the Citizens' Association referred to, which at first was merely obstructive in its tactics, proposing nothing, but merely opposing the Common project; but its leading spirits soon perceived the tactical error of a mere attitude of opposition to doing something, and placed themselves in the sounder position that a subway under Tremont St. was a better plan for all concerned. To them chiefly belongs the credit of the present result. When so many prominent Boston citizens have put their shoulders to the wheel it seems invidious to mention single names, but it is but just to say that Mr. George B. Upham, who acted as counsel and agent for them, deserves a large share of the credit for its successful work. Among the newspapers the Boston "Traveller" has been conspicuous for its zealous and successful efforts in the same direction.

These influences were sufficient to induce the legislature to pass a bill (reviewed in detail in our issue of June 22, 1893) authorizing the city to expend $2,000,000 on this subway by mere vote of the city government, at the same time that an elevated railway project was to be submitted to vote of the people. It was justly held that action on the subway should be postponed until the people had voted on the elevated railway project, the vote being assumed to be in fact, though not in form, an expression of the popular choice between them. The popular verdict being against the elevated railway, if not in favor of the subway, the city government, led on by an urgent and broad-minded message from the mayor, has accepted this verdict by a vote of 11 to 1 in the Board of Aldermen and of 62 to 2 in the Common Council. It now rests with the mayor to appoint a commission of three to carry out the work, and we know that he is taking especial pains to select an earnest, active and capable one, which will probably be announced shortly.

There are 5,925 lighthouse stations in the world, according to the British Admiralty lists. Of these England has 817; the United States, 802; Canada and Newfounland, 494, and France comes fourth with 441 lights The whole of Europe has 3,477 lighthouses or stations.

LETTERS TO THE EDITOR.

EARLY STEEL BRIDGES IN AMERICA.

Sir: Can you put me in the way of ascertaining a reliable list of the early bridges of American manufacture which were either entirely or partly constructed of steel, and the dates of construction of the same? The only data I can put my hands upon is the following list which I feel uncertain about and which is very unsatisfactory. I feel sure a reliable list of all the important structures which were built when steel first began to be used would be of interest to the profession.

Very truly yours,

Samuel Tobias Wagner, M. Am. Soc. C. E.

Wayne, Pa., Dec. 16, 1893.

(The following is the list of early steel bridges sent by our correspondent. We shall be glad if any of our readers will send additions to this table, which will then be republished.—Ed.)

Date.	Name.	Steel made by—
1869	St. Louis	Butcher.
1879-83	East River Bridge	Cambria Iron Co.
1880	Plattsmouth	
1881-82	Bismarck	Spang Steel & Iron Co.
1883	Blair	Cambria Iron Co.
1883	Willamette	Spang Steel & Iron Co.
1883	Niagara Cantilever	Spang Steel & Iron Co.
1883	Point Pleasant	Spang Steel & Iron Co. Cambria Iron Co.
1884	Henderson	Cambria Iron Co.
1884	Port Deposit	Carnegie Bros

CONVENTIONAL LOADS FOR CALCULATING BRIDGE STRAINS.

Sir: In Professor Johnson's "Theory and Practice of Framed Structures," Chap. VI., Conventional Methods of Treating Train Loads, there is a statement concerning the method of two excesses to the effect that this method has never come into general use, the objection being either that it does not sufficiently shorten the work to warrant its use in place of the more exact method, or that no rational method has been proposed for finding the proper values of the excess loads.

Probably every bridge engineer has, during some period of his practice, endeavored to arrive at a process which could be substituted for the wheel moment tables or diagrams. Mr. Thacher proposed the uniform load now being agitated by Mr. Waddell. Mr. Pegram proposed a single excess, and various other methods of more or less practical value have been mentioned and used as substitutes for the specified engine and train load. Either the uniform load or the single excess can be substituted for an engine, but require a mass of preliminary work in making tables or in deriving the proper excess, and this necessitates the possession of a complete moment table for the engine specified. If these tables are not on hand, and an engineer should be called upon to make a proposal, the preliminary work would bar out either of the above methods; the calculator would, in all probability, prepare a moment table and figure stresses from actual wheel moments, unless he knew of a simple method which would require no moments and would represent the actual engine.

In the writer's opinion, the method of uniform load with two excesses has many advantages over any method so far proposed. It requires no tables, practically no preliminary work, and is as accurate as any method ever used. The excesses can be easily determined in a rational manner for any specified engine and train, the uniform load being that given as the train load. It shortens work as much as does the single excess method.

The excesses can be determined from the following simple formula:

$$E = \frac{E'\left(p - \frac{B}{4}\right)}{2p} \qquad (1)$$

Where E = one excess.

E' = excess of weight of two engines and tenders over that of the train load covering an equal space.

p = length of panel.

B = the wheel base of drivers of one engine "dist. c. to c. of wheels."

For finding shearing stresses, take one excess at panel point considered and the other two panels removed, and consider the uniform load as covering the bridge to such a distance as will give the maximum shear in the panel considered. End chords should be figured for the above excesses, but intermediate chords can be figured for a uniform load derived from train load and one excess by the following formula:

$$w = w' + \frac{2E}{L} \qquad (2)$$

L = length of span. Where: w' = train load.

This method should not be used for spans under 100 ft. in length. The greatest difference between this and the wheel moment method for chords and main ties for two extremely different types of consolidation engines is as follows for spans between 100 ft. and 300 ft.: Cooper's Class A, 85.5 tons, followed by

3,000 lbs. per lin. ft; chords + 1.49% and −1.52%; main ties + 0.00% and − 2.1%.

C. R. R. of N. J., 126 tons, followed by 4,000 lbs.; chords + 2.77% and − 1.49%; main ties + 0.46% and − 3.65%.

The 2.77% excess given for chords in the second class occurs in the center panel of a 100-ft. span, the next highest excess being 1.53% in the center panel of a 125-ft. span. All other chord stresses for any span above 125 ft. will vary between + 1.53% and − 1.49%, the variation decreasing as the length of span increases. The 3.65% scantage occurs in the first main tie next the center in a 150-ft. span, and in all other cases there is no scantage greater than 3% and this always near the center of the bridge.

The stresses in counters figured in the manner indicated will be scant from 10 to 15%, and to cover this 15% or 20% should be added to the figured stresses in all counters. If the uniform load be divided up into panel concentrations and that part going to the panel point in advance of the point considered be neglected, the shear in all the main ties and counters will be in excess of actual stress shears by amounts varying from 0.0% to probably 25% in first counter. Since these excesses increase as the dimensions of the web members diminish, they affect the actual sections required to an inappreciable extent, are on the safe side and would not make a difference in the totol weight of structure of 0.1%. This is the practice followed by the writer when not using wheel moments.

The writer believes this method of determining the two excesses is original, and was decided upon as being the closest approximation of a large number of assumptions as to the proper distance over which the engine excess should extend. It will be seen from formula (1) that the excess of one engine is considered as distributed over the actual driving wheel base "B," in other words between the centers of the first and last drivers, and that when this distributed excess is placed over a panel point, the actual concentrated excess E is only that part of the total excess $\frac{E^1}{2}$ which goes to the panel point considered. That part going to the adjacent panels is entirely neglected. It may also be mentioned that the space covered by the two engines and tenders is the distance center to center of the first and last wheels plus one-half the distance between the last wheel of tender and the first wheel of following train. This assumption should not be overlooked when determining excesses.

Yours truly, J. E. Greiner,
Engineer of Bridges, B. & O. R. R.
Baltimore, Md., Dec. 1, 1893.

LAYING CAST IRON PIPE ON CURVES.

Sir: Replying to "E. R." in the last number of Engineering News, under "Notes and Queries," I would say that on the Mayfield extension of the Gloversville water-works we laid 18-in. cast iron pipe of 12-ft. lengths on a curve of 181-ft. radius for a distance of 600 ft. in a 25-ft. cut and had no trouble with it. I would like to hear the experience of others.

Yours truly, J. B. Tuckerman,
Supt. and Engr.
Gloversville, N. Y., Dec. 16, 1893.

BRICK PAVING FOR HORSE CAR TRACKS.

Sir: I would like to inquire through your journal if there is anything on record going to show that brick pavement put down between the rails of a street railway track, over which horse cars are used, has ever proved satisfactory, with any other than a good concrete foundation. Street car horses or mules have a faculty for always stepping in the same places, which will cause a settlement of the bricks when over sand or cinders. Very truly yours, S. E. Moore.
Memphis, Tenn., Dec. 6, 1893.

REVISION OF NYSTROM'S POCKET-BOOK.

Sir: Being engaged in the revision and correction of the 20th edition of "Nystrom's Pocket-Book of Mechanics and Engineering" I should take it as a favor if you or your readers would apprise me of any errors of omission or of commission in that valuable standard work, in order that they may be corrected in the 21st edition. Yours truly, Robert Grimshaw.
171 West 95th St., New York, Dec. 1, 1893.

(Nystrom's Pocket-Book has a great many very strong points. Its general style and form are, perhaps, the best of any of the pocket-books, and we trust will not be lightly changed.—Ed.)

THE FRICTION OF FREE ROTATION OF ROLLERS FOR BRIDGES.

Sir: If a law applicable to the above subject has been made known I have not seen it. I send you a formula, in the absence of a full demonstration, by which the resistance of cylinders of all diameters can be accurately ascertained. The roller is supposed to be a smooth, clean iron cylinder placed between two clean, smooth iron plates. The bedplate is supposed fixed; the top plate movable on roller. The weight and power that moves the roller are applied to top plate. All the rollers under one end of span are represented by one roller, and all the weight that would be supported by all the rollers is supposed concentrated on this one roller. The formula is:

$$P = \frac{3\,W\,f}{2\,D}.$$

In which P = the frictional resistance, W = the weight of roller and load, f = the ratio of the friction to the pressure and D = the diameter of roller. In one revolution of roller the center of roller moves a distance equal to the circumference of roller, and every point in the top plate moves a distance equal to twice the circumference of roller during the same revolution, describing a line which would be the evolute or circumference of a circle of double the diameter of roller. The value of the friction depends on the double velocity of the moving power.

Everything in the second member of formula is constant, except D, the diameter. It follows that the resistance of friction varies inversely as the diameter of roller. The result here secured agrees with the results of numerous experiments of Coulomb on wooden cylinders, one of which was a 3-in. cylinder of mahogany rolling on a plane of oak, the friction was one-sixteenth of the pressure and rolling on a plane of elm the friction was only 1-100 of the pressure. This principle indicates the reason that small driving wheels of locomotive engines have more adhesion or friction than larger wheels, and are, therefore, capable of hauling greater loads with the same weight on axle; that is, the power of engine varies inversely with the diameter of driving wheels.

M. McCabe.
Pontiac, Ill., Dec. 4, 1893.

(The rolling friction will undoubtedly vary inversely with the diameter, but we have no confidence in the absolute value of the friction given by our correspondent's formula. It is based upon the wrong principle. There is no rubbing friction, except in a very indirect and indeterminate form which defies analysis. Therefore, the coefficient of friction should not enter into the formula. The rolling friction is a function of the elastic compressibility of the roller and plate which can only be determined experimentally for each particular case, and which should in any case be much less than 0.25, which our correspondent uses in an inclosed illustrative computation.—Ed.)

THE GOODCHILD COMPUTING CHART.

Sir: Your notice of the chart by Mr. C. W. Goodchild in Engineering News of Nov. 9 has led me to send for one, and with the chart I also received a letter inclosing a sheet which I forward to you (by permission), as it seems that there are a good many people interested in devices of this sort, and you may, perhaps, consider it of sufficient value to print for the benefit of your readers.

Mr. Goodchild says in explanation of the chart:

> This chart consists of four of my charts mentioned in Engineering News of Nov. 9, 1893, so arranged that the upper line contains the first two lines, the second the second and third, etc. The gridiron chart contains a single scale of numbers, but may also have one of angles. This scale should be made a little longer than half the first, so that the numbers at the end of a line may be repeated on the next.
>
> To multiply, place the initial point of the gridiron on one number in the northwest corner, then the other number on the gridiron will point out the product.
>
> To divide, place the divisor on the dividend in the southeast corner and the initial point of the gridiron will give the quotient.
>
> Squares may be read off under the lines in the northwest corner, and cubes in the northeast corner. These will not interfere, as they will be covered by the gridiron when in use.
>
> With initial numbers (as on my chart) on the large chart, and a scale of equal parts on the gridiron logarithims could be read.
>
> If the two upper scales were on a cylinder, and the gridiron on a revolving cylinder, it would make a pocket slide rule.
>
> The size of the cylinder and the number of lines thereon could, of course, be increased ad libitum.
>
> C. W. Goodchild.
> San Luis Obispo, Cal., Nov. 18, 1893.

Mr. Goodchild says, in an accompanying note to me: "The objection that has been made by some mathematicians to whom I have submitted the chart is the want of a method of self-manipulation. While I still think that the beauty of the chart consists in its simplicity, and that it is preferable to any slide rule (outside of the question of accuracy) when several successive operations have to be performed (for the successive characteristics may be carried with the initial numbers on the measuring card), I have contrived a method by which the above objection is obviated and take the liberty of inclosing a rough diagram and explanation."

Very respectfully, H. S. Jacoby.
Ithaca, N. Y., Dec. 8, 1893.

THE ELASTIC THEORY FOR MASONRY ARCHES.

Sir: Reference is made by the author of the article on "Masonry Arches in Galicia" (Engineering News, Dec. 7, 1893) to the "elastic theory for obtaining the strains." Kindly advise me where further infomation and explanation of this theory can be read in English. The effort of translation from the Austrian and the digesting of the abstruse information would affect the ductility of the average brain. I infer that the "Gewoelbe Comite" spoken of gave no idea of the theory, which is supplemented by the author of your article.

It would be interesting to have a more detailed description of the design of these and similar masonry structures so numerous on the continent.

Yours truly, R. A. C.
Philadelphia, Pa., Dec. 11, 1893.

(Such information may be found in Bakers' "Masonry Construction" and more in detail in "Trusses and Arches, Part III., Arches" by Professor Green.—Ed.)

NOTES AND QUERIES.

C. A. reports another case of "magnetic variation" in a survey, due to the disturbing influence of a steel wire stiffener in a derby hat, similar to the case reported by a correspondent in our issue of Dec. 21. Apparently slouch hats will have to be added to four-in-hand neckties as the prescribed dress for the engineer on survey.

M. W. L. inquires whether unused tees and crosses cause considerable friction when placed in a pumping main to a reservoir. The conditions are as follows: A 36-in. main five miles in length leads to a reservoir 280 ft. above the pumps. It is proposed to place 6 and 8-in. plugged tees and crosses about every 500 ft. for convenience in making future connections. What effect would these have upon the capacity of the pumps?

The slight increase of friction caused by the proposed plugged specials would be much more than offset by their convenience and economy in making future extensions.

LEGAL DECISIONS OF INTEREST TO ENGINEERS.

Powers of Contractors When Paving Streets.

Contractors under a contract with a city to pave a certain street have no power to obstruct the passage of street cars over such street where the contract gives no such power and it is shown that such work has been, and can be, done without such interference. Milwaukee St. R. Co. v. Adlam, Supr. Ct. of Wis., 55 N. W. Rep., 181.

Right of Council to Reject Bids.

Where a city charter requires that the furnishing of material for public works shall be given to the lowest bidder, but there is a proviso that the council may reject any and all bids, this proviso in the charter was to obtain the materials and the work at the lowest possible cost to the taxpayer, after competition among bidders; and the proviso was intended for the same public interest, to protect the taxpayers from imposition, and, while inviting competition, to secure good material and responsible contractors. While the city council would not be justified and the courts would not intervene to protect the taxpayers in such event to arbitrarily reject a bid and thus defeat the object to be attained by competition, it is vested with a certain discretion in rejecting bids, which will not be controlled when exercised with prudence, in the public interest.

Gunning Gravel Co. v. City of New Orleans. Sup. Ct. La. 13 So. Rep. 182.

Determination of Boundaries of Highways.

It is the settled law of this state that the determination of the boundaries of a street requires action of a judicious nature to ascertain the precise character and extent of the encroachment, and that parties affected by the adjudication have a right to be heard. Furthermore, that this judicial function must be assumed and exercised by the proper municipal body with special reference to the street affected, and a mode must be provided in which the adjacent property owners may be heard.

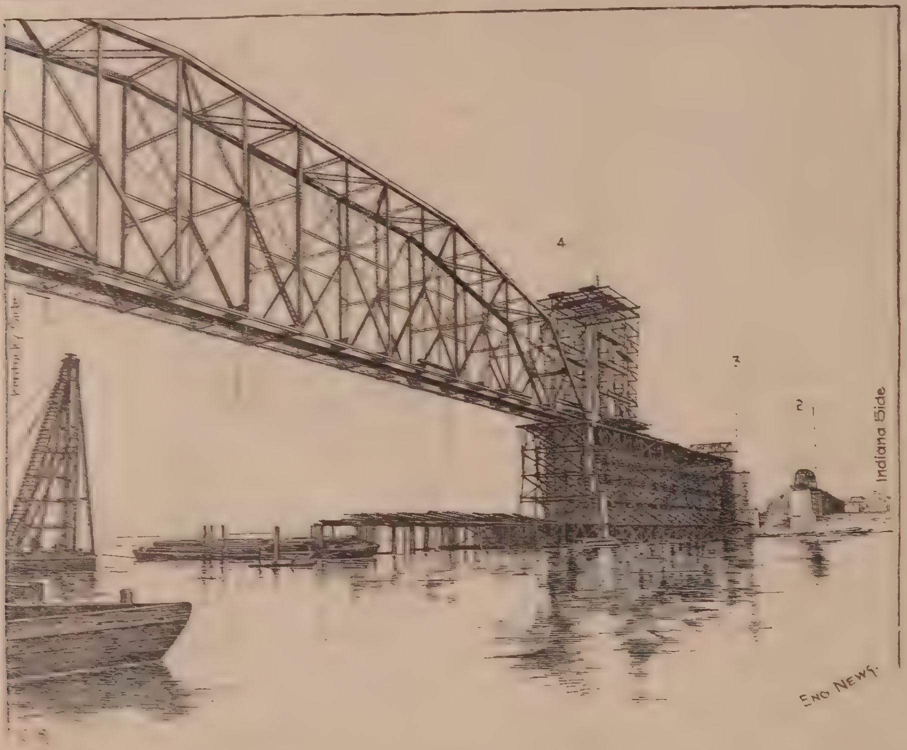
Voorhees v. Borough of Bound Brook. Sup. Ct. N. J. 26 At. Rep. 710.

THE LOUISVILLE & JEFFERSONVILLE BRIDGE DISASTER.

(With inset.)

In the number of lives lost and the amount of property destroyed, the terrible disaster which occurred on the Louisville & Jeffersonville Bridge on Dec. 15, as briefly noted in our last issue, is by far the most serious accident of the kind in the history of American bridge building, unless we may possibly except the very similar collapse of the Licking River bridge in June, 1892 (Eng. News, June 23, 1892), which resulted in a greater loss of life but a much smaller loss of property. We have made particular efforts to secure all the facts in connection with the accident, and are enabled to lay before our readers this week a very complete statement of the circumstances. This information has been obtained from a number of sources and includes, besides the statements from the various local newspapers and the records of the work on file in this office, a special report from Mr. Edwin Thacher, M. Am. Soc. C. E., who made an investigation at our request, a letter from Mr. John Stirling Deans, M. Am. Soc. C. E., Chief Engineer of the Phoenix Bridge Co., and full details of the falseworks, the traveler and the iron and steelwork of the fallen spans, the latter furnished by the Phoenix Bridge Co., the contractors for the construction and erection of the superstructure.

The history of the Louisville & Jeffersonville Bridge has been an extremely checkered one. The first company organized for the purpose of building this bridge from Louisville, Ky., to Jeffersonville, Ind., was chartered in 1879. Practically nothing was done in the way of actual construction, however, until nine years later, 1888, when the Louisville & Jeffersonville Bridge Co. was chartered. Plans were prepared and submitted to the Secretary of War, who approved the location Feb. 28, 1889, and the complete plans Nov. 15, 1889. In October, 1889, the contract for the substructure was let to Sooysmith & Co., of New York city, and for the superstructure to the Phoenix Bridge Co., of Phoenixville, Pa. Work was begun on the substructure the same month.



SKETCH SHOWING SPAN 3 AND FALSEWORKS FOR SPAN 4, LOUISVILLE & JEFFERSONVILLE BRIDGE WHICH FELL DEC. 15, 1893.

The plans provided for a single track railway bridge having six spans carried on three concrete-filled iron cylinder piers and four masonry piers, as shown in the general elevation on the inset sheet. The lengths of the several truss spans and the iron trestle approaches were as follows:

	C. to c. of end pins. ft.	C. to c. of piers. ft.
Span 1	208½	219
" 2	515½	530
" 3	546½	558
" 4	546½	556
" 5	338	341
" 6	338	341
Total length of bridge proper		2,545
Length of Indiana approach		4,073
Length of Kentucky approach		2,740
Total length of ironwork		9,358

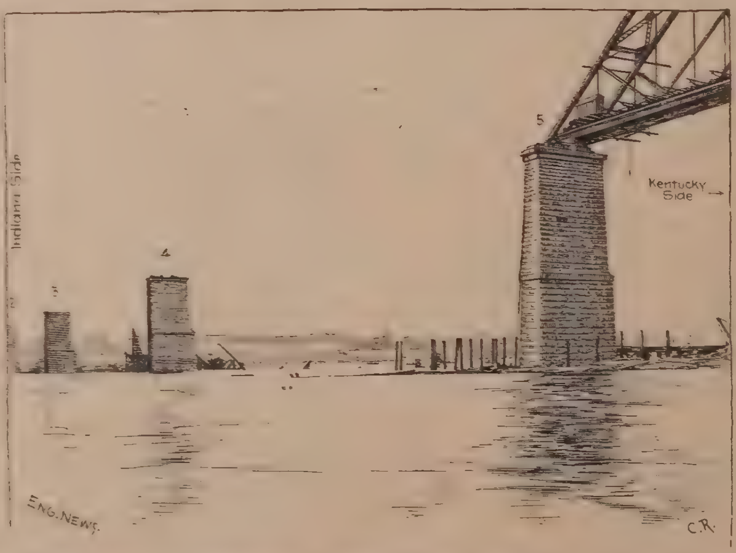
The substructure consists of seven piers, of which Nos. 1, 6 and 7 are oblong iron shells, with semi-circular ends, filled with concrete and the remainder are stone masonry. For all of the iron cylinder piers ⅝-in. iron was used, but the dimensions of the shells vary, being for Pier 1, 24 × 7 ft.; for Pier 6, 28 × 8 ft.; and for Pier 7, 28 × 7 ft. The shell for Pier 1 rests on solid rock and for Piers 6 and 7 on piles. Pier 2 is built of stone and concrete and rests on rock at a depth not much below low water. It is rectangular in form above high water line and has a semi-circular up-stream end below the high water line. Piers 3, 4 and 5 are of stone masonry resting on timber caissons. The caissons were sunk by the plenum-pneumatic process. In sinking the caisson for Pier 5 the first serious accident occurred, an inflow of water on Jan. 9, 1890, drowning 14 men (Eng. News, Jan. 18, 1890). This was followed by a second accident on May 14, 1890 (Eng. News, May 24, 1890), when the caisson which was being sunk for Pier 4 overturned, killing seven men. Work was continued without further serious accident until early in 1891, when, owing to financial difficulties, it was discontinued. At this time the substructure was practically completed and the shortest span of the superstructure (210 ft.) had been erected.

The financial difficulties of the company were not finally adjusted until about the middle of the present year, when a new contract was made with the Phoenix Bridge Co., and work on the superstructure was resumed.

The general features of the ironwork are shown in the elevation on the inset sheet and the lengths of the several spans are given in the preceding table. Details of one of the 546½-ft. spans which fell are also given on the inset sheet. There were three of these spans, which are, we think, the longest pin-connected truss spans ever erected. The only other truss span very closely approaching them in length is the 545-ft. span of the Ohio River Bridge at Cincinnati, O. This bridge, it is somewhat curious to note, suffered a similar accident by having the falsework under the 545-ft. truss swept away while the truss was being erected on Aug. 26, 1888. With the falsework fell the traveler and 13 panels of the ironwork which had been erected. The two 546½-ft. spans of the Louisville & Jeffersonville Bridge were identical in all respects, and their details are so fully given in the illustration on our inset sheet as to make any further description superfluous.

Turning now to the accident itself, a brief explanation of the drawings may be necessary. The first of the sketches (which are made from photographs, one taken a few days before and the other just after the accident) shows one of the long spans in position and the falseworks for the other. It will be remembered that the falseworks and partly finished ironwork of span No. 4 fell about 10:20 a. m., Dec. 15, and the adjacent span, No. 3, which was practically completed, at about 8 p. m. This last span is the one shown completed in the photograph referred to. The second sketch shows the appearance of the river a day or so after the fall of the second span. The almost complete absence of debris above the water will be noticed. This is due partly to the fact that the timber work had been largely cleared away to recover the dead bodies or had floated off after falling, while the ironwork was completely submerged by the water, which is between 30 ft. and 40 ft. deep at these points. In the general elevation on the inset sheet the spans which fell are designated by the letters A and B, and the pier numbers correspond with the pier numbers in the sketches. The construction of the falseworks is also shown on the inset sheet and the construction of the traveler used in erecting the ironwork in the accompanying cut in the text.

Both spans fell on Dec. 15 and the following letter from Mr. John Stirling Deans, Chief Engineer of the Phoenix Bridge Co., was mailed to us on Dec. 18, which gives very fully the facts and conclusions which he arrived at after a personal investigation:



SKETCH SHOWING APPEARANCE OF BRIDGE AFTER THE FALL OF SPANS 3 AND 4.

Sir: Fortunately it is rarely necessary for an engineer to be called upon to report upon such a serious accident as has been met with in the construction of the Louisville & Jeffersonville Bridge over the Ohio River at this point. The Phoenix Bridge Co. are the contractors for the superstructure of this work, and they desire to place before the engineering public, through your paper, a full and detailed description of

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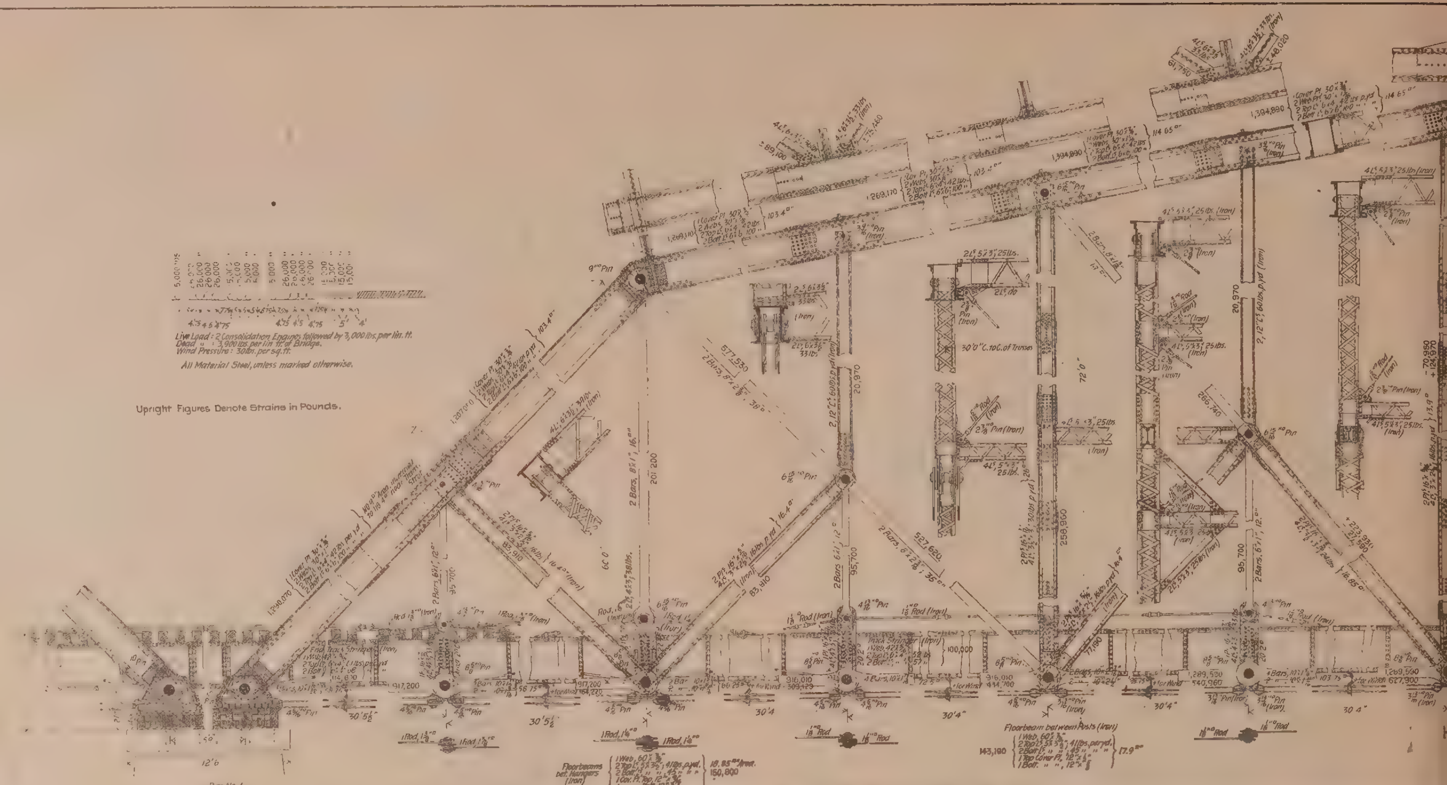
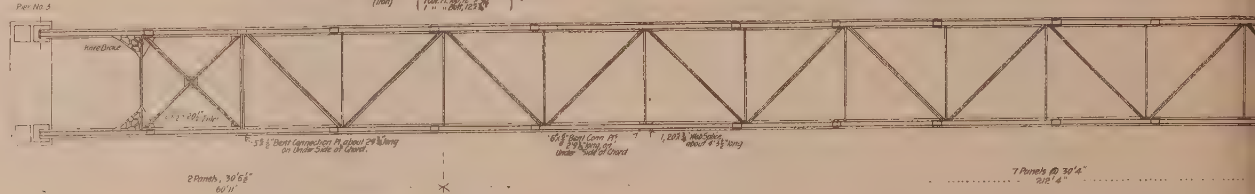
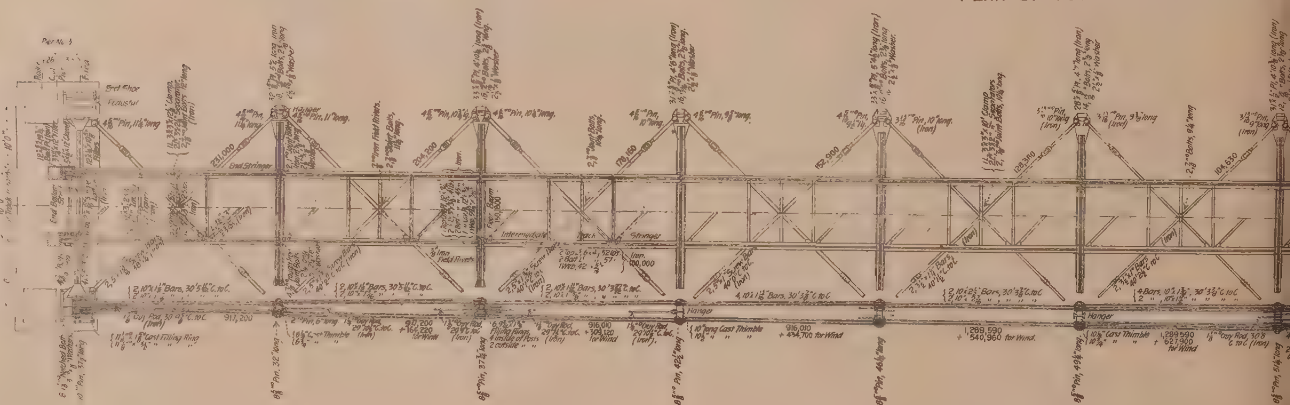

Live Load: 2 Consolidation Engines followed by 3,000 lbs. per lin. ft.
Dead " : 3,900 lbs. per lin. ft. of Bridge.
Wind Pressure: 30 lbs. per sq. ft.
All Material Steel, unless marked otherwise.
Upright Figures Denote Strains in Pounds.
Floorbeam between Posts (Iron)
Floorbeams bet. Hangers (Iron)



PLAN OF TOP LATERAL BRACING.



PART PLAN OF BOTTOM LA

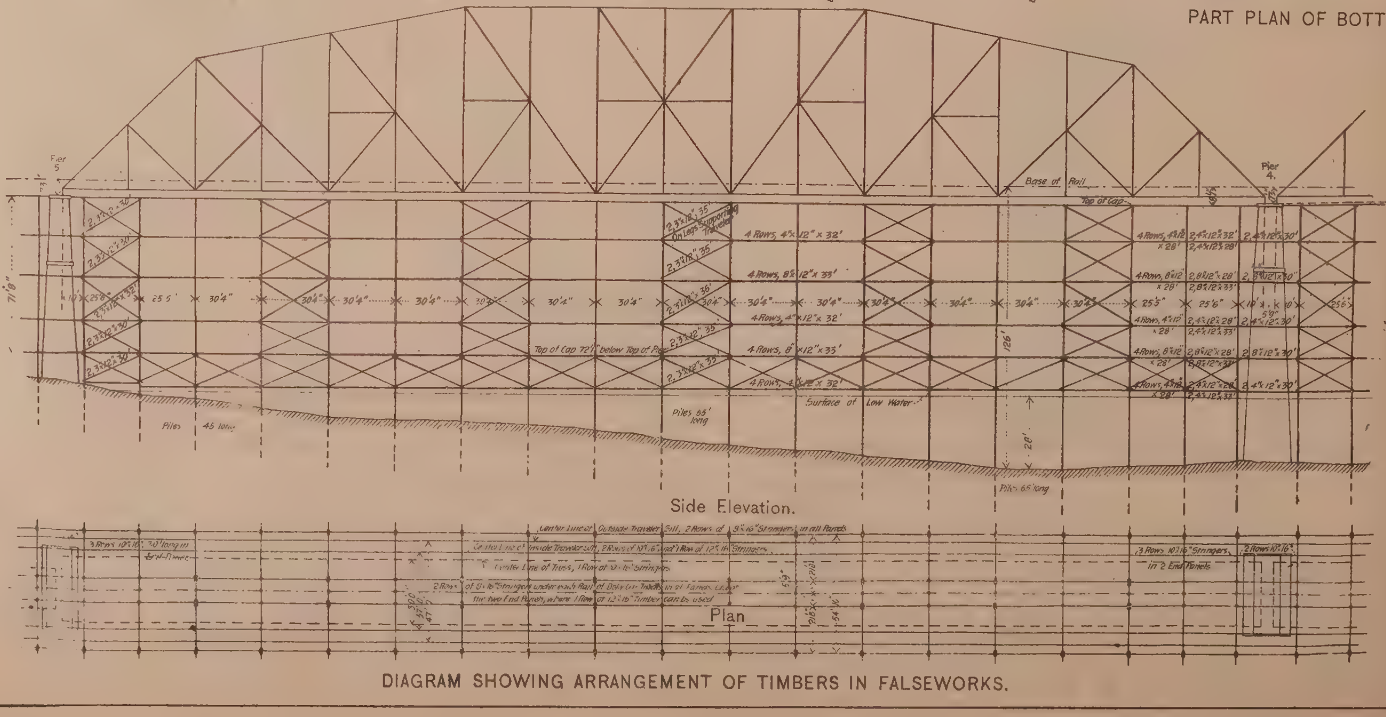


DIAGRAM SHOWING ARRANGEMENT OF TIMBERS IN FALSEWORKS.

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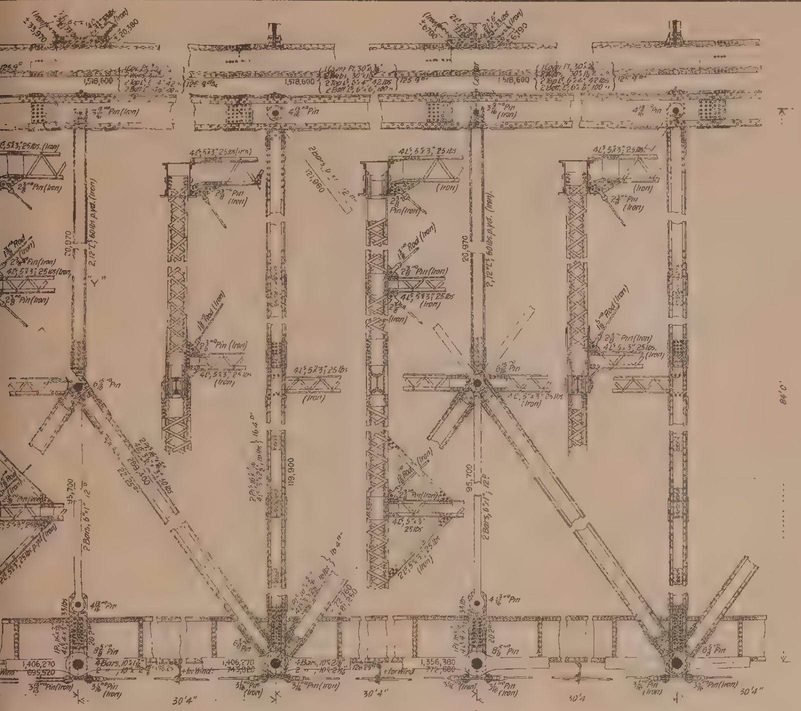
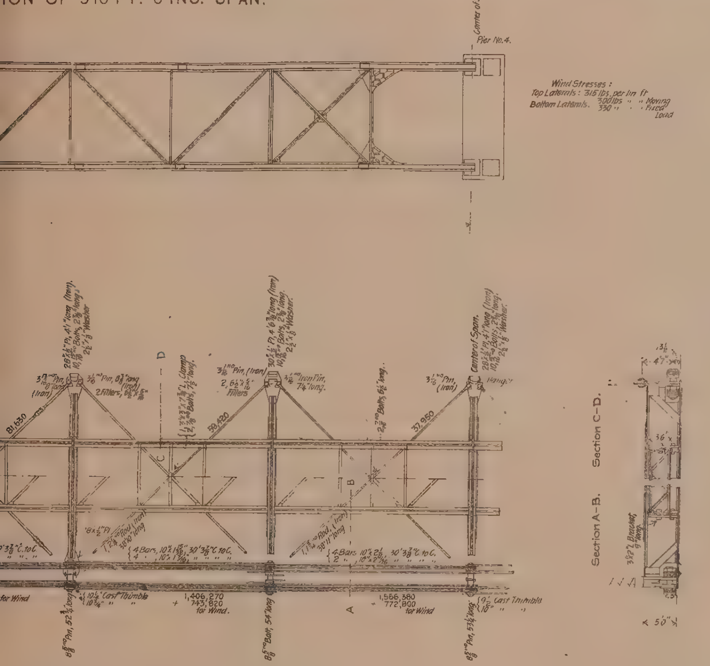
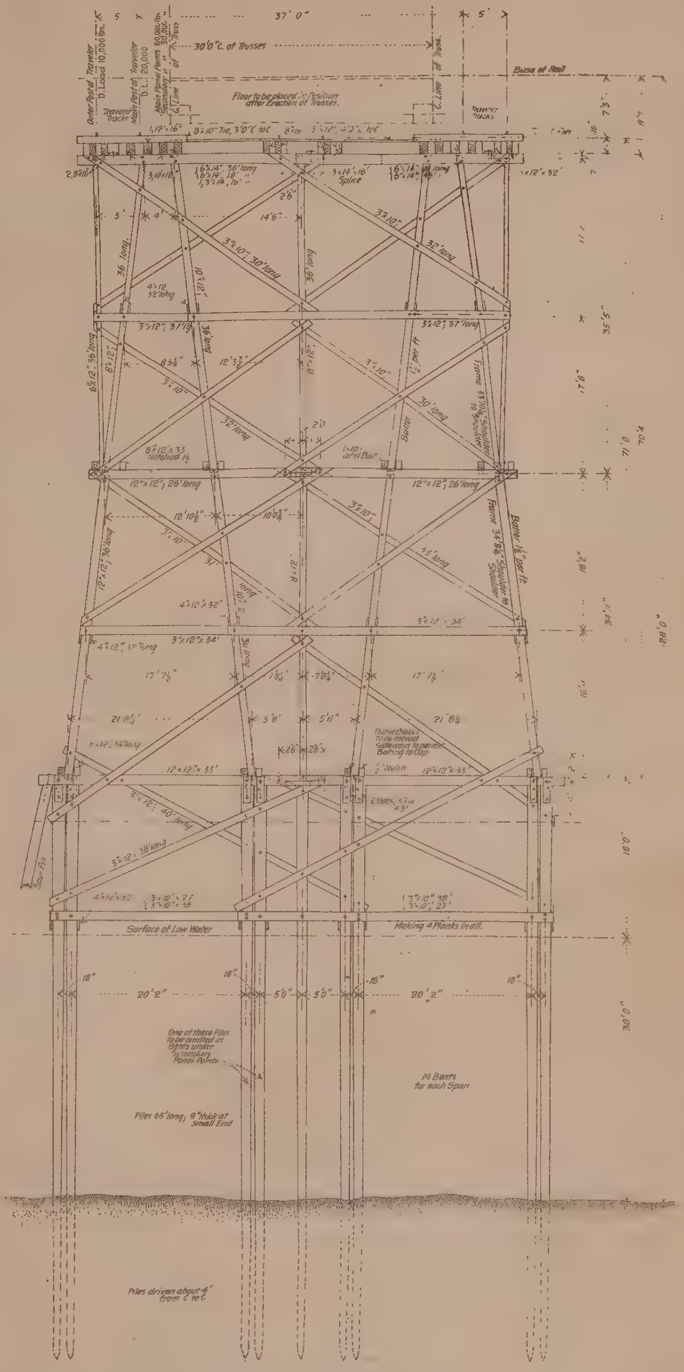


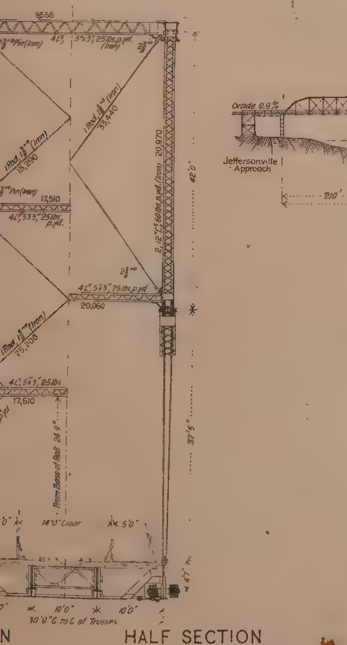
ION OF 546 FT. 6 INS. SPAN.


Pier No. 4.
Wind Stresses:
Top Laterals: 315 lbs. per lin. ft.
Bottom Laterals: 300 lbs. Moving, 350 Fixed Load
Central Span.
Section A–B.
Section C–D.
A
B
C
D

CING AND FLOOR SYSTEM.

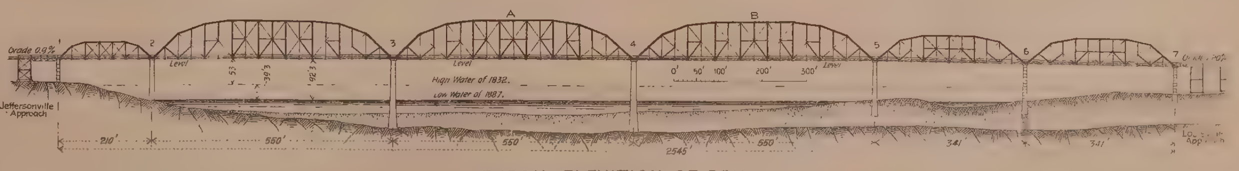

37'0"
30'0" C. of Trusses
Base of Rail
Floor to be placed in position after Erection of Trusses.
Traveler Track
Surface of Low Water
20'2"
5'6"
5'6"
20'2"
One of these Piles to be omitted in Bents under Panel Points
14 Bents for each Span
Piles 65' long, 9" thick at small End
Piles driven about 4' from C. to C.

CROSS SECTION OF FALSEWORKS
SHOWING CONSTRUCTION OF BENTS.



N
T X.

HALF SECTION
SHOWING AUXILIARY POST Y.



GENERAL ELEVATION OF BRIDGE.

LOUISVILLE AND JEFFERSONVILLE BRIDGE, LOUISVILLE, KY.

[Details of Falseworks and Iron Work of Spans which Fell December 15, 1893.]

Phoenix Bridge Co., Phoenixville, Pa., Contractors.

CHAS. HART & SONS, LITH., 86 VESEY ST., N. Y.

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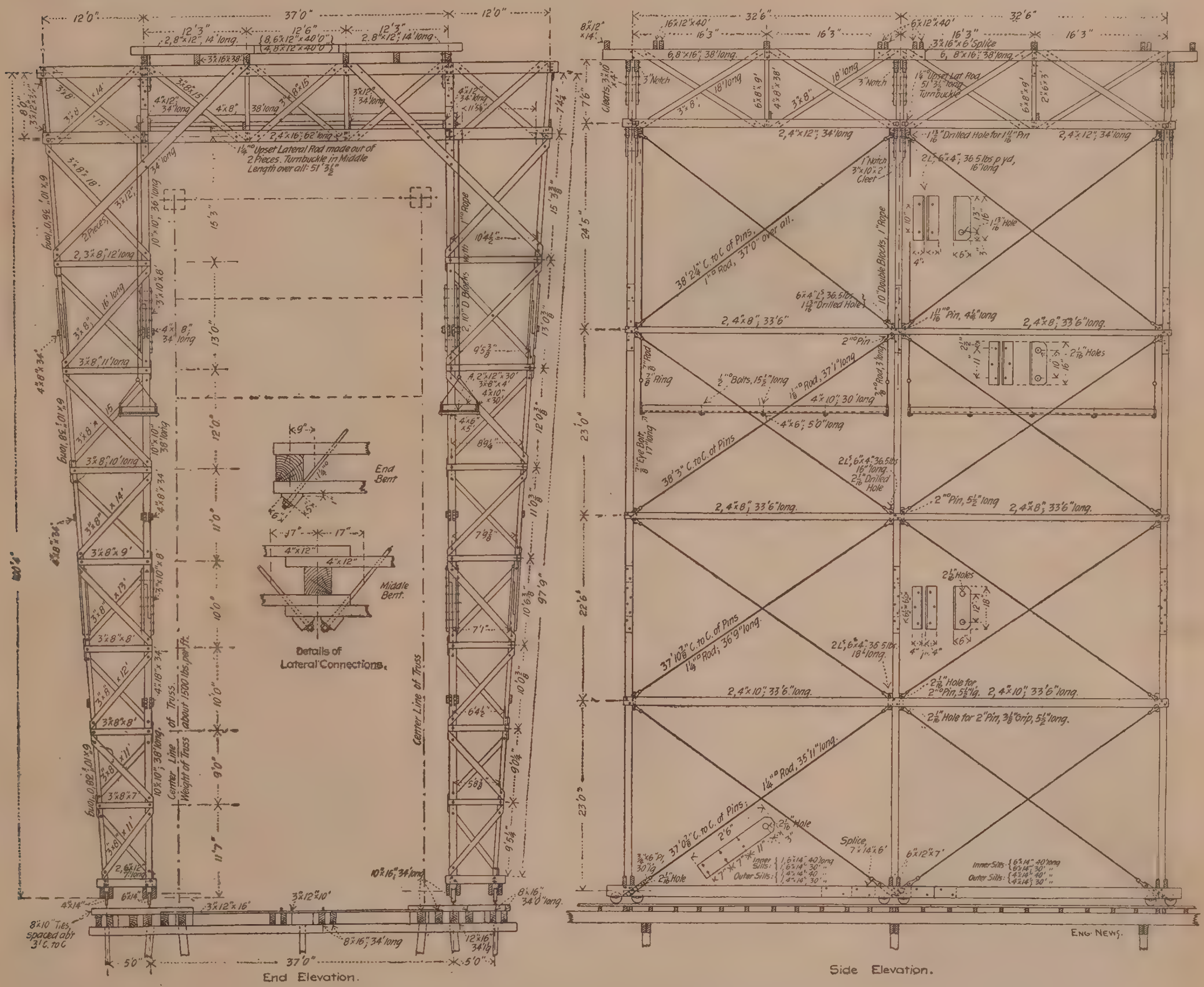
their plans for the permanent superstructure and their plans for temporary falsework and traveler, and they also desire to place before engineers a complete description of the facts regarding the causes of the accident as far as they have been able to locate them after a complete investigation. This they desire to do, not alone for their own protection, but to give engineers throughout the United States the benefit of their sad experience here. To this end we have mailed to you a general plan of the entire bridge, a full detailed plan of one of the 546½-ft. spans, a detailed plan of the falsework, and a detailed plan of the traveler, and to these drawings the following report refers. (These drawings are all given on our inset sheet and in the accompanying cuts.—Ed.)

The river portion of the bridge in which we are particularly interested consists, beginning with the Louisville side, of two 338-ft. single-track through spans, three 546½-ft. single-track through spans and one 208½-ft. span. At the time of the accident, on Dec. 15, 1893, the two 338-ft. spans were complete in every particular and falsework removed, having been finished about Oct. 15. One 546½-ft. span had all material in place and falseworks removed, with ties and rails in position. The second 546½-ft. span had all of the falseworks in place and seven double panels of the trusses with upper laterals and transverse bracing in place. In the third 546½-ft. span the falseworks was being put in place from each end, three bents in place on the Louisville side and eight bents in place on the Jeffersonville side. The last span, the 208½-ft. span on the Jeffersonville side, had been entirely completed for a year and a half.

Falseworks.—The sizes and details of the falseworks are shown clearly in the drawings. The piling was new, first-class selected yellow Southern pine, and was driven with a 3,200-lb. hammer; the penetration into the bed of the river varying from 10 to 16 ft. In no case was a less number of piles driven per bent than are shown on the plan, and in a number of instances where it was thought a perfect bearing or perfect work had not been secured an additional pile was put in. Additional diagonal bracing was also put in at a number of points both longitudinally and transversely, and also considerable lateral bracing immediately at the tops of the piles. This extra material was put in in no special and systematic manner, but was simply an extra precaution at any point where the superintendent in charge of the work thought that it was needed to make it doubly secure and as protection against high water and ice. The falseworks material was all new Southern yellow pine, and had not been used before this work. It must be borne in mind that one of the 546½-ft. spans had been erected successfully on falseworks in exact accordance with the plan and in water at least 10 ft. deeper than was any time found during the raising of the falseworks for the second 546½-ft. span. The traveler was constructed of new Southern yellow pine timber, and was especially designed, as will be seen, to offer as little resistance as possible to the wind, iron rods being used instead of timbers for longitudinal bracing. The traveler, as those engineers familiar with erection are aware, is not necessarily a stable structure under wind pressure, and is provided at each corner with guys and also at each bent with transverse guys to be used during wind storms. These were all in place and ready for such an emergency when the accident occurred. The traveler was rigged with four hoisting engines on the plane of the lower sills, two engines on each side.

The First Wreck.—The conditions immediately preceding the first wreck were as follows: The ironwork of the trusses of the second 546 ft. span had been erected from the fixed, or Louisville end, and up to a point within two double panels of the Jeffersonville end on the night of Dec. 14, 1893, and the traveler was left at this point guyed securely for the night and with the last chord sections connected, but still attached to the lines. The men at the time of quitting work on the last panel on Thursday evening had started to drive the lower downstream chord pin through the truss and lower chord. The next morning when they came to continue their work they found this joint exactly in the same condition as when they left it the night before; absolutely no settlement had occurred, and the pin was driven home without delay. The traveler was then unguyed and unlashed from the metalwork and moved ahead to start raising the next double panel.

It must be borne in mind that the falseworks at this point had no load upon it with the exception of the traveler. The weather was blustery at the time the traveler was moved, and as the falseworks immediately under it showed signs of slight swaying and movement upstream, it was thought to be best, as a matter of precaution, to pull the traveler back to its first position in the morning and send men down to put on additional bracing at the level of the pile caps to hold the falsework at that point more securely. A sketch was immediatly made by Superintendent Milliken of the manner in which this was to be done, and



End Elevation.
Side Elevation.
Details of Lateral Connections.
End Bent
Middle Bent
Center Line of Truss
Center Line of Truss, Weight of Truss about 1500 lbs. per ft.
12'0"
37'0"
12'0"
32'6"
16'3"
1¼" Upset Lateral Rod made out of 2 Pieces. Turnbuckle in Middle. Length over all: 51'3½"
1" Rope
10" Double Blocks, 1" Rope
38'2½" C. to C. of Pins, 1" Rod, 37'0" over all.
Splice
8"x10" Ties, spaced abt 3' C. to C.
5'0"
Eng. News.

DETAILS OF TRAVELER USED IN ERECTING IRONWORK.

Mr. McKee, the general foreman in charge of the work, started down, and with a gang of men was soon on his way with the steamboat and barges with extra bracing to attend to this work, having left instructions with his traveler foreman to move the traveler back so that piling could be relieved and this bracing put on.

The blustery condition of the weather increased as the day passed, and it came in squalls, and while the traveler was being unguyed and blocking being taken out to move back, a sudden squall struck it at an angle, and, from the reports secured, twisted it to the right, and probably threw it off of the traveler rails, although this cannot be positively stated. At least it is evident that it was lifted on the windward side and practically all of the weight was thrown on one corner. This crushed down the bent and piling immediately under the support, and without a moment's warning, not giving the men time to run 50 ft., it went down. The traveler evidently did not blow over, but simply settled down with the falsework upstream, as the upstream engines were in their proper position with even the tools in the tool chest undisturbed. This seems to bear out the supposition that immediately after the squall passed and had done its work, the traveler regained its position and settled down with the wrecked falsework. Of course, the condition of the partially finished span was such that immediately on the giving away of this bent the whole structure necessarily came down, as there was a tendency, of course, to push toward the Jeffersonville end. The wreck and loss of life were awful, but within ten minutes it would have been much more than it was, as Mr. McKee with his men and steamboat would soon have been directly under the traveler, putting on the additional bracing which was thought necessary.

The Second Wreck.—A number of the men who were working immediately adjoining the Jeffersonville pier, some 17 in all, had time and presence of mind enough to get on the top of the masonry, and these men, with a coolness which is simply remarkable, immediately took measures, even in the midst of this terrible wreck, to fasten the three bents of falsework immediatly adjoining the pier which had been erected for the third long span. This falsework consisted of three full bents thoroughly braced and on top a falseworks, traveler with engines and boiler, and rigging. They took fire lashings of 1½ in. line around these bents and falsework and around the pier, and had this work done in about 15 minutes. About five minutes after this another terrible gust of wind struck the pier, forcing the men to lie down, and twisted the falsework traveler to the right in the same manner as the main falsework was twisted, and blew the whole of the falsework and traveler into the river. This was the second accident, and all thought it was the last. The men in the steamboat who were to put on the extra bracing immediately turned all their energy to rescuing the poor fellows who had gone down with the span. Those killed were taken out, as well as a number of injured and a number who were not hurt, the total number going down being about 52.

The Third Wreck.—This work of rescuing the men was continued all the afternoon and into the dark of the evening, when at about 8:20 o'clock, without a moment's warning, a sound was heard like the roaring of cannon. The men on the wreck were blown down on their faces, the pile driver near the Jefferosnville pier was nearly upset, and in the midst of all of this confusion the first 546½-ft. span was blown into the river. The force of the winds at the level of the water was terrific, and lasted but a moment, but in the air, some 125 ft. above and on a level with the trusses, it must have been something terrible. The span, as above stated, had been erected some three weeks, all of the material was in place, the floor system had been riveted complete, the floor beams being riveted between the posts and the stringers between the floor beams and all the upper lateral bracing portals, transverse bracing, upper chord joints and intermediate post joints were thoroughly bolted up and riveting was progressing. At least four-fifths of all the holes were filled with bolts. This we know positively to be the case, as it was the subject of special instructions to the foreman about ten days or two weeks before the accident happened, and a special gang of men was sent over to put in this full number of bolts after the regular and ordinary number of bolts had been put in as the span was being erected. In addition to this the ties were temporarily in place, being spaced about 3 ft. centers with rails in position and spiked down, and over this span we had run all of the heavy iron and material for the second span. The span, including the floor, ties and rails, weighed at least 2,000,000 lbs. Our method of erection was as follows, and will be seen by those familiar with work of this character to be the method generally used:

The trusses, including the upper lateral bracing and the transverse bracing, are first put in place, and the span is then swung off without any floor or lower laterals in position, and as fast as the falsework is removed this floor and lower laterals are put in place. All contractors appreciate that in the interval between the swinging of the trusses and the placing of this floor and lower laterals there is a period of anxiety should a severe storm be met with. We had several such here; some so severe that the men could not walk, but saw no signs which gave us any anxiety, and it is unexplainable to us how a span in the condition in which this first 546½-ft. span was on Dec. 15, 1893, could have been blown down by anything but the most extraordinary force. From the location of the wreck in the river it is evident that the span did not collapse and was not blown directly down, but lifted, as the bottom chord, including the floor, is all on the bottom of the river with the upper ends of the end posts and the upper chords above them and showing above the water. The piers also give no evidence of the spans dragging over them; in fact, the roller frame with pedestal above it is intact on the Jeffersonville end, and the fixed pedestal with the anchor bolt nuts stripped off is on the Louisville end.

The direction of the wind was the same as in the case of the disaster to the falsework, being at an angle and striking the fixed end first. This end was forced at least 35 ft. up the river before it fell. It would look reasonable to suppose that the roller end would be forced off first, but such was not the cause. The greatest force of the wind existed at the fixed end of the structure. Had the span collapsed, it would, of course, have dropped immediately between the piers and dragged off the masonry; but this is found not to be the case. Had the transverse bracing yielded, it would have forced the upper chord over and it would have been found in the bottom of the river; but this is also not found to be the condition of affairs, and it must evidently have been lifted directly off of its supports and blown up the river.

Weather.—We are securing from the Government Signal Service observer here a full detailed statement of the condition of the weather at the time and immediately preceding the wreck. There was evidently cyclonic indications, as was generally stated in the papers. The weather was hot and sultry, and we understand that between 5 p. m. and 8 p. m. is the time when cyclones are to be expected in this vicinity when the conditions are favorable. We have not had time to collect data regarding the course of the storm at other points. We have simply information that a short time after the accident here a cyclone struck Muncie, Ind., and immediately preceding the wreck here there was a cyclone or at least high winds in southern Kentucky. The regular report of the signal service observer at Louisville only shows a velocity of 36 miles per hour, but any engineer can readily prove to himself that such a pressure could not dislodge a span of this magnitude, even though it were carelessly constructed and erected. We are continuing our investigations and shall give engineers the benefit of anything we learn on the subject.

The number of lives lost, we fear, will foot up a total of 21; seven bodies have been recovered and 13 men are missing. This is simply appalling and shows the suddenness with which the disaster occurred, as the men could have been in a place of safety if they had only received two minutes' notice. The individual examples of heroism among the men were numerous, and the coolness with which they proceeded to assist their unfortunate associates in the midst of all the terrors of the wreck could not but excite admiration and could only be shown by such experienced and hearty men as bridge erectors are well known to be.

We may state that after the falsework for the second 546½ ft. was in position and we started to raise the iron, we experienced a rise in the river of about 10 ft., and at the time of the wreck the river had fallen until the water was about 6 ft. above low water, shown on the plans.

Should further investigation develop anything of interest to the profession or that will throw any light on this terrible disaster, we shall at once forward the same to you for publication.

Yours truly, Jno. Sterling Deans,
Chief Engr. Phoenix Bridge Co.
Louisville, Ky., Dec. 18, 1893.

We have also received a letter from Mr. Deans reaffirming the conclusions stated in his first letter and giving some additional information. This is as follows:

> Sir: Replying to your letter we beg to state that we have no additional information which we can give you concerning the terrible disaster at Louisville. We notice, however, in "Engineering Record" of last week that their conclusions are based upon wrong assumptions, and as we are all exceedingly desirous to learn the true cause of this disaster we think these matters should be corrected.
>
> (1) The falsework had been in the river about two weeks before we started to raise iron, and had been subjected to a flood of at least 10 ft. during the greater part of this time, and from investigations made before and since the wreck we think possibly that at least some scour took place in the bents immediately adjoining the Indiana pier.
>
> (2) Three lines of X bracing, as shown on the plan below, the top of the piles extending from pier to pier, were in position at least one week before the accident and before any metal work was put on the falsework.
>
> (3) The floor system was riveted complete, ready for traffic, and the balance of the work was thoroughly bolted up with at least four-fifths of the field holes filled with rivets. The joint at the lower end portal strut contained at least 70 of these fitting-up bolts. All the lower laterals had been put in starting from the roller end, with the exception of the two end panels near the fixed end, but the span could not have failed from this cause or failed in the plane of the lower laterals, as shown from the fact that if it had failed from this cause the lower chord on the windward side would have been buckled and the span would have fallen downstream. This is found not to be the case, as it fell upstream and the fixed end was blown at least 35 ft. above its support.
>
> (4) The upper lateral bracing and transverse bracing, as before stated, were thoroughly bolted. The span, if it had buckled or given way in the upper lateral bracing, would have been forced over and the intermediate posts would have been broken near the support to floor system, and we would expect to find the floor system extending above the top of the water and on top of the upper chord and interior post, but such was found not to be the condition of affairs, as you will see from photographs.
>
> (5) Had the span broken at the lower end portal strut it would have been forced and rotated about the upstream leeward end post and there would have been signs of this movement on the pedestal and on the masonry as the end shoe left the pier, but no signs of this action is found, and the condition of the wreck in the river forces us to the conclusion that the span was lifted near the fixed end and then blown a sufficient distance up the river to clear piling projecting some 15 ft. above the water and extending about 100 ft. from the Kentucky pier toward the Indiana pier, as will be seen from the photographs.
>
> The Phoenix Bridge Co., in conjunction with other contractors and engineers, have nothing to lose, but everything to gain, from the thorough description of this terrible calamity, and our only idea in writing you on the subject is to state the exact and correct facts as we found them, to assist in arriving at the correct cause. We assure you that any further information which we may receive will be promptly forwarded.
>
> Yours very truly, The Phoenix Bridge Co.
> Jno. Sterling Deans.
> Chief Engineer.
> Phoenixville, Pa., Dec. 26, 1893.

In an interview published in the Louisville "Courier-Journal" of Dec. 18, Mr. Deans gives in substance the same explanation of the accident to the falseworks of the first span that is given in the above letters and says:

> In regard to the falling of the second span I will have to ask you to go to Almighty God for the cause. After I had made an investigation of this wreck I was astonished. I can't account for it at all, and I can safely say that no one else can. That great span, which was almost completed, and which weighed 2,000,000 lbs., was lifted bodily from the piers and set down in the river fully 25 ft. above the bridge. It never turned over once in its fall and is in the same position, 40 ft. in the bottom of the river, as it stood on the piers. I examined the piers carefully and they were not even scratched. The rollers and pedestals on which the span had rested were on top of the piers just as they had been placed there, and there was nothing to indicate that there had been a crash. It seemed as if the iron had been lifted carefully, piece by piece, from its resting place, and carried away. If the span had not been lifted off the piers, the condition of these things would be far different, as any one can see. I don't think this could have been done had the wind been of a velocity less than 75 to 90 miles an hour.
>
> The span had been connected for more than a month, and had stood many a strong wind, and for a long time it had no bracing whatever. Several days before the accident it had been well braced and was constructed to stand a pressure of wind of 30 lbs. to the sq. ft. This was estimated on the presumption that a long freight train was upon the span. Now, there was no weight on the span at all; nothing on it at all, and, of course, the resistance to the wind was not so great as if a train had been upon the span. I know this appears to be a remarkable statement, because of the fact that the boats in the river, the other two spans and the houses on the banks were not touched or affected by the wind. My private opinion in explanation is that a cyclone dropped down and plucked that span off. This is all the way I can account for it.

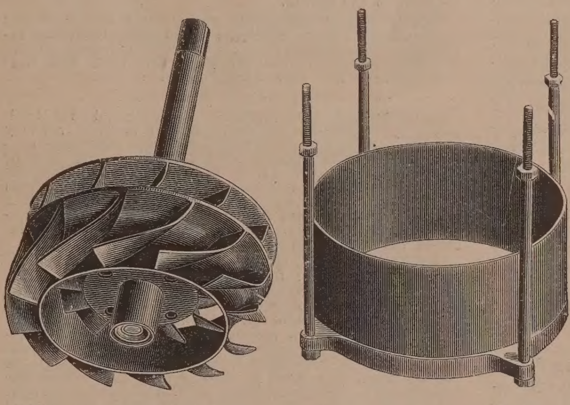
In the same issue of the above paper Mr. G. J. O'Connor, the official on duty at the local Signal Service Station, at the time of the accident, states that while a local windstorm existed during the evening of Dec. 15, there was nothing in shape of a tornado. The highest wind recorded by anemometer was 36 miles per hour. For ten minutes only the instrument showed an average velocity of the wind of 34 miles per hour. In reporting an interview with Mr. Frank Burke, the official in charge of the local Signal Service Station, the Louisville "Times" says:

> Mr. Burke said that the idea of a tornado was absurd. He said that while the wind blew very hard at the time of the second accident its velocity was nothing unusual. General weather conditions yesterday were such that a tornado was not impossible, but it was almost certain that none occurred in this vicinity. Tornadoes do not traverse a thickly settled territory without leaving some trace. It is extremely improbable, if not impossible, that one could strike the bridge and not make its presence felt elsewhere. A ferryboat was passing the bridge at the time of the second collapse and it must have felt the tornado had there been one. Mr. Burke says the wind was no harder than it frequently is during thunder-storms. While the velocity at the bridge might have been slightly greater than that registered at the weather office, he does not think it could have been over 40 miles an hour.

Mr. McKee, the general foreman in charge of the erection, who was at work superintending the rescue of the bodies buried in the debris of the first span at the time the second span fell, states that the wind was blowing so hard that he had to grasp a line to keep from being carried into the river. The statements of various other persons confirm one or the other of the above statements, but give little additional information. The general tenor of the evidence is that a high wind was blowing at the time that the second span fell, but there seems to be no direct evidence that there was anything like a tornado.

The following is the report of Mr. Edwin Thacher, M. Am. Soc. C. E., who made a special investigation of the accident at our request:

> Sir: I met Mr. Deans, Supt. Milliken and Mr. McKee, general foreman of erection, at the office of the Phoenix Bridge Co. on Campbell St., near the bridge site, on the morning of Oct. 17. I examined the plans of falseworks and traveler, and also viewed such portions of the wreck as remain above water, which is a very small portion of the whole.
>
> Span No. 3 (546½ ft. c. to c. of pins) that fell at 10:20 a. m., Dec. 15, was supported by 19 bents of falsework, one at each panel point and one at each pier. The traveler was standing with its center three panel lengths from the north end of span, the span being erected from the south end complete up to this point. Like all large travelers it was top heavy and unstable against a strong wind. At the time of the accident the guys ordinarily in use for holding the traveler steadily in position were slackened preparatory to moving it, the falsework below having given some signs of weakness, probably due to the undermining of the supporting piles by scour, as the current was quite rapid and the bottom of the river of soft material. At this time a strong wind, probably not less than 40 miles per hour, came from the southwest, striking the falsework and traveler diagonally. The uplifting and twisting action of the wind on the traveler, which, with its engines, coils of rope and rigging weighed from 90 to 100 tons, was probably sufficient to throw the greater part of this weight on one corner, under which accumulated weight the weakened falsework gave way. From all the facts that I have been able to gather this appears to me the most probable cause of the accident. The plans show nine piles under each bent of falsework. These piles were driven to refusal with a 3,200-lb. hammer. The bents appear to have been thoroughly braced transversely and longitudinally, and the bridge company seems to have taken every ordinary precaution to insure the safety of its work.
>
> The cause of the fall of span No. 4 (duplicate of span No. 3), which occurred at 8:10 p. m. on the same day, is more difficult to account for, and so far as I know it has no parallel among bridge disasters. All falsework had been removed; all rivets in floor system had been driven, and the bottom laterals were all connected and adjusted. (A later letter from Mr. Thacher states that he had learned since this report was written that the bottom lateral bracing of the two south end panels was not in place.—Ed.) The top chord sections were bolted together temporarily with sixteen ⅞-in. bolts at each panel point. The top lateral, portal and diagonal bracing were secured temporarily by bolts, about eight out of ten of the holes being filled. A bridge in such condition is usually considered safe against any ordinary wind, and there is no evidence of a cyclone in the immediate vicinity of the bridge or in the cities at either end. The end braces (inclined end posts.—Ed.) are spliced at the center near the foot of the portal braces, and, being only temporarily bolted, were not prepared to take the bending moment due to any considerable amount of wind. As this was unquestionably, to my mind, the weakest point of the bridge, I have little doubt that the end braces were the first to give way and the collapse of the structure followed. But a small part of the wreck appears above water. Only a few posts and struts appear in the north half of opening and they are about in line with the center of the piers. In the south part of the opening the end braces and some few other parts of the bridge can be seen. One end brace, bottom end up, with bolster attached, can be recognized. This part of the wreck is lodged somewhat above the east end of pier. The wreck apparently lies diagonally across the opening. If the end braces at the south end of span were the first thing to give way, a twisting action would be brought to bear on the span, overturning the south end and dragging the north end off the pier, and the position of the wreck, so far as can be seen, would seem to confirm this theory.
>
> Yours truly, Edwin Thacher,
> M. Am. Soc. C. E.
>
> Louisville, Ky., Dec. 18, 1893.


Wheel Removed from Case. View of Cylindrical Gate.

THE WALSH DOUBLE TURBINE, B. H. & J. Sanford, Makers, Sheboygan Falls, Wis.

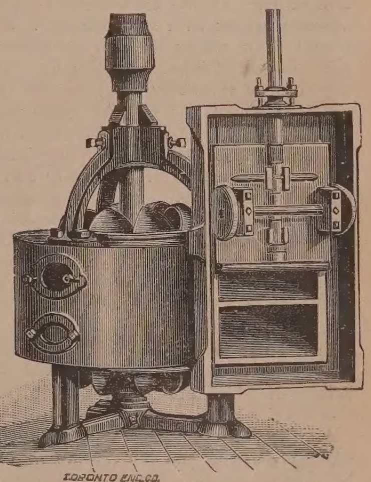
In regard to the failure of the falseworks and the fall of the first span, it will be seen that Mr. Thacher's conclusions agree substantially with those of Mr. Deans, and pretty well establish the reasons for the failure. With respect to the fall of the second span, however, there is a difference of opinion. We have discussed this point more at length in our editorial columns and will only call attention here to the evidence which has been given. From this and the very complete details of the design of the end braces and their connections, given on our inset sheet, bridge engineers will be able to form their own opinion as to the cause of the fall.

In conclusion, it may be stated that the loss of life will be fully as great as was stated last week. At present 7 dead bodies have been taken from the debris and 13 men are still missing, most, if not all, of whom are undoubtedly dead. These, taken with the two men reported fatally injured, brings the number of lives lost up to 21 or 22. With the 21 men killed in the two caisson accidents, referred to above, this number makes the appalling aggregate of 42 lives lost in building this bridge, without counting such single lives as may have been lost during the work, of which we have no record. The loss of property is stated to be $150,000. It is also stated that as soon as practicable, steps will be taken to rebuild the fallen spans and complete the bridge.

WATER WHEELS AT THE COLUMBIAN EXPOSITION.

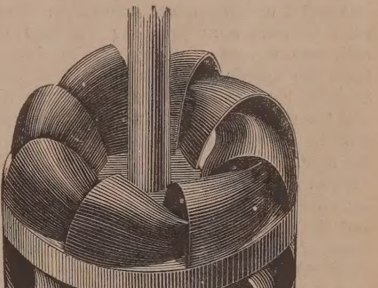
Considering the rapid increase in the use of water power for generating electricity and the consequent growing importance of hydraulic motors, the exhibits at Chicago in this class were certainly disappointing, first, in the small number of makers represented, and, second, in the fact that the exhibits were so scattered in various buildings that most visitors probably saw the exhibits of only one or two makers.

The credit for making the most complete exhibit in this department must certainly be awarded to the Stilwell-Bierce & Smith-Vaile Co. for their exhibit of the well known Victor turbines. These were shown in both horizontal and vertical styles. The latter is fitted with either a register gate or a cylinder gate as preferred. The efficiency of the turbine at partial gate is probably somewhat more with the register gate, which operates by adjusting the opening in the guide passages; but the cylindrical gate works more easily, is simpler and is generally preferred for use in sandy water. Both horizontal and vertical turbines are made with draft tube, which can be extended to any desired length if it is necessary to set the wheel some distance above the tail race.


TORONTO ENG. CO.

THE "LITTLE GIANT" TURBINE, J. C. Wilson & Co., Pictou, Ont., Makars.

A turbine with some novel features was shown by B. H. & J. Sanford, of Sheboygan Falls, Wis. The wheel is double with a horizontal plate dividing the two sets of entry buckets, and a vertical annular partition dividing the two sets of discharge buckets. It is claimed for this arrangement that the wheel works with as high efficiency at half gate as at full gate. The water enters at the circumference of the wheel and is discharged at the bottom, half way between the circumference and the center. The gate used is cylindrical and differs from other cylindrical gates in raising to shut off the flow, and being wide open when in its down position. When the gate is down it forms a short draft tube. It is also claimed that this gate is not liable to be clogged by sand or pebbles lodging in its seat, as is the gate with its seat at the bottom. Thus the gate can be closed watertight. The gate is raised by four vertical rods engaging a yoke; thus it is guided in a vertical position and will not stick or bind.


Wheel of Little Giant Turbine Removed from Case.

In the exhibit of R. D. Wood & Co. was one of the Jonval wheels built by them for the Niagara

Falls Paper Co., water for which is to be furnished by the new water power development works at Niagara. The wheel was designed by Mr. Emil Geyelin. It is of solid phosphor-bronze, and measures 4 ft. 10 ins. across. The speed is governed by gate valves throttling the flow in the pipes leading from the base of the penstock to each wheel.

A turbine with a wheel similar to the Geyelin was shown by Briegleb, Hansen & Co., of Gotha, the leading German turbine makers. The wheel had a rather complicated folding gate, consisting of a series of iron plates which slide together like the blades of a fan as the gate is opened. Thus the effect is to shut the water off from the blades around part of the circumference and leave the others working with full efficiency. Such a wheel should show nearly as high an efficiency at part gate as at full gate, which is not the case with any form of throttling gate; but the cost and complication would not suit American turbine users.

J. C. Wilson & Co., of Picton, Ont., showed vertical and horizontal turbines of the double discharge type. Water enters at the center and passes half upward and half downward, thus balancing the reaction and avoiding excessive pressure on the step. The buckets deliver the water tangentially at the top and bottom. The gate in the entry pipe is of the vertical sliding type and is mounted on wheels to ease the motion when the water pressure is against it.

In the Mining Building Jas. Leffel & Co. showed one of their well known horizontal turbines, the details of which are too familiar to need description here.

All the turbines which we have described, except the Geyelin and the turbine shown by Briegleb, Hansen & Co., follow the common custom of using a wooden step and a three-piece wooden bearing for the upper end of the turbine shaft. That this plan has its merits for the ordinary locations in which turbines are placed is undeniable; but that some more durable material like fiber-graphite or vulcabeston, or, perhaps, some of the metals will eventually take its place seems an equally safe guess.

Regarding governing of the wheels, which is the present weak point in water wheel practice where electric lighting service is concerned, it appears to be certain that the common plan of throttling the flow of water to the wheel can never effect either successful or economical governing. The best results in governing thus far obtained have been with the governor throttling the flow of water from the wheel; and this method of governing is likely to be specified in the near future where electrical service is desired, unless the wheel is of a type in which movable guide blades can regulate the flow.

The rapid growth in popularity of electric motors has checked the use of small sizes of water motors, and the only machines of this type exhibited were those of the Belknap Motor Co., of Portland, Me. This wheel is a small turbine and the makers claim that its construction is more solid and durable than that of most small size water motors on the market.

The only wheel of the impact type on exhibition was the well known Pelton, one of which was shown in the Electricity Building mounted on the same shaft with a General Electric dynamo. The wheel has two nozzles and is provided with the new governor which the company has recently brought out, which operates like the old to throttle the flow back of the nozzle, a system which must apparently be wasteful of power. Of course with wheels of this type, throttling the flow in the pipe is the only feasible method of governing. It would be an advantage of course if it were possible to throttle by a variable nozzle instead of by a valve back of the nozzle; but the mechanical difficulties in the way of doing this are perhaps insurmountable.

CONSTRUCTION NEWS.

RAILWAYS.

East of Chicago—Existing Roads.

ADDISON & PENNSYLVANIA.—The extension of this railway from Galeton to Austin, Potter county, Pa., has been opened. It is expected that it will be further extended to connect with the Pine Creek in the spring. Pres., T. C. Platt, New York.

BALTIMORE & OHIO.—It is reported that the State Line road, extending from Uniontown, Pa., to a connection with the Fairmount, Morgantown & Pittsburg at the state line, a distance of 22 miles, will be opened for traffic next month.

BANGOR & AROOSTOOK.—The tracklaying on this railway has been completed to Houlton, Me., and it is expected that in the spring the construction will be resumed and the line continued north 83 miles to Presque Isle and Van Buren. Practically all of the track on the line to Houlton has been laid this year, and much of the grading, particularly on the lower section near Brownville, has been completed in 1893. The new work begins at Brownville, on the old Bangor & Piscataquis, which is now controlled by this company, and the route is northeasterly through Penobscot and Aroostook counties to Houlton, a distance of over 90 miles.

BUFFALO & SUSQUEHANNA.—Press reports state that this railway will soon be extended from Gaines, Pa., to Ansonia, Pa., and that work on the rock cuts along the line will be commenced next month. Pres., F. H Goodyear, Austin, Pa

FLINT & PERE MARQUETTE.—Press reports state that the right of way has been secured between Monroe, Mich., and Toledo, O., for a new line which will be built in the spring.

TOLEDO & OHIO.—It is stated that this company contemplates more extensive yard and terminal facilities at Columbus, O., than were provided for in the first plans for the proposed belt line, and that new surveys are now being made.

Projects and Surveys.

BALTIMORE NORTHERN.—Incorporated at Baltimore by capitalists of that city to build a railway from a connection with the Baltimore Belt to a connection with the projected York & Schuylkill west of Delta; capital stock, $1,000,000. When completed the two roads will form a line 135 miles in length, from Baltimore into the anthracite coal regions of Schuylkill county, Pa., which are controlled by the incorporators of the roads. The line is said to be in the interest of the Baltimore & Ohio.

DOMINION COAL CO.—It was reported some months ago that a contract for constructing 10 miles of this railway from the colliery at Glace Bay, through Cow Bay and toward Louisburg, in Cape Breton, had been awarded to McDonald & McManus, Moncton, N. B. The company is now asking for bids, according to reports, for the grading and masonry of a section of the proposed road, extending from a point near the Back Lands Road, Cow Bay, to a point near the end of the twenty-third mile from Bridgeport, a distance of about nine miles. Contractor must begin work at once on being notified of the acceptance of his tender, and must finish the work before September, 1894.

NOVA SCOTIA COAST LINE.—The contract has been awarded for building this proposed railway from Yarmouth to Lockeport, N. S., according to reports.

Southern—Existing Roads.

FLORIDA CENTRAL AND PENINSULAR.—The extension of this railway has been completed. The line extends from Columbia, S. C., to Jacksonville, Fla., with branches to Pensacola, Tampa and other places in Florida. A press report from Washington states as follows: The opening of another great through line of railway travel between the North and South, shortening the distance and quickening the time, is announced for Dec. 24, when the Richmond & Danville R. R., in connection with the newly constructed line of the Florida Central & Peninsular from Savannah, Ga., to Jacksonville, Fla., and the purchase by it of the Southbound R. R. from Columbia, S. C., to Savannah, makes one complete line of railway from Washington to Tampa, Fla., on the Gulf of Mexico. The Richmond & Danville has been selected by the government as the route for the Southern fast mail and by this new route mail will leave Washington at 11 o'clock every morning, and be in Jacksonville the next morning at 9 o'clock, and all over the state of Florida many hours in advance of any other schedule now in effect. New York and Eastern passengers can leave New York at 4:30 p. m. every day, reaching Jacksonville at 9 p. m. the next day and Tampa the following morning.

TENNESSEE CENTRAL.—The Nashville "American" states that W. H. Brennan and Lee McAdoo have left the city to organize a surveying corps to run a line from Cookeville to Harriman for this railway, and that the Nashville & Knoxville road is now completed from Lebanon to a point 17 miles beyond Cookeville, which is only 60 miles from Harriman on the Cincinnati Southern.

Projects and Surveys.

KENTUCKY.—A press dispatch from Duluth, Minn., states as follows: Wolf & King, railway contractors of this city, have secured a contract for building 60 miles of railway in eastern Kentucky, connecting the coalfields of Pike county with the Big Sandy River at Whitehall. The contract is for about $600,000, and work begins soon. Interests in these coalfields were sold a year ago by ex-Governor Proctor Knott to people in this city interested in iron and steel manufacture. The coal is said to be of the finest coke quality.

MONROEVILLE & NORTHWESTERN.—An exchange states as follows: Arrangements have been completed for building a 10-mile section of this road. This is intended to form a part of the Pensacola & Northern, a railway projected from Pensacola to Memphis, Tenn., 430 miles. The road is open between Pensacola and Muscogee, Ala., a distance of 25 miles. Of this length, the Pensacola & Perdido road, which is leased to the Pensacola Northern supplies 15 miles. Another line which is intended to skirt a part of the Florida west coast, and which may become an extension of the Pensacola Northern, is termed the Gulf & Florida Northern, which is projected from St. Andrew's Bay to Apalachicola, about 215 miles distant. Engineer Cailey has begun surveys from Chipley, Fla., on the Louisville & Nashville, which has given rise to a theory that the road's northern terminus at present will be that town.

Northwest—Existing Roads.

CHICAGO & NEW ORLEANS.—The contract for grading, bridging and tracklaying for this railway between Paducah, Ky., on the Ohio River, and Farina, Ill., where a connection is made with the Illinois Central, a distance of about 130 miles, was awarded to Oliver Ferguson & Sons, Evansville, Ind., in 1891, and some grading was done on the line. Press reports now state that bids are being received on 10,000 tons of steel rails to be used on the line, and that the road in connection with the Illinois Central will form a through line from Chicago to the South and Southwest, reaching entirely new territory.

Projects and Surveys.

MIDLAND PACIFIC.—Press reports state that an attempt is being made to reorganize this company, which projected a railway several years ago from Sioux Falls to Puget Sound, 1,400 miles. It is thought that J. Kennedy Tod & Co. are backing the project, and that attempts will be made to build this next year from Sioux Falls to the Larrabee coal mines, which have recently been purchased by the promoters of the Wyoming & Pierre Ry.

WYOMING & PIERRE.—It is stated that the incorporators of this railway company have purchased extensive coal mines in the Black Hills and will commence in the spring the construction of a railway from Minneseia, S. Dak., to the mines, a distance of 17 miles. The Chicago, Wilmington & Vermillion Coal Co., Chicago, is interested.

Southwest—Existing Roads.

ST. LOUIS, CAPE GIRARDEAU & FORT SMITH.—A report from Perryville, Mo., states that the engineers of this road have completed the survey of a line from that place to Lathium and are now working on a route to Chester, Ill.

Projects and Surveys.

KANSAS, OKLAHOMA CENTRAL & SOUTHWESTERN.—Both houses of congress have passed a bill granting this company a right of way through Oklahoma and Indian Territory. The proposed route, according to reports, is from Stillwater to Guthrie, thence to El Reno and through the Kiowa and Comanche country. The company was incorporated last summer by Robt. Martin, Guthrie, Okla., and others.

OKLAHOMA CENTRAL.—A press report states that the articles of incorporation of this railway company have been agreed upon and adopted fixing the line of road as nearly as possible in a straight line from Sapulpa, Ind. T., through Oklahoma City to the Texas boundary on the Red River, near Vernon, on the Denver & Fort Worth road, and ultimately to El Paso. When completed, this route will furnish the shortest railway line from St. Louis to California by nearly 400 miles. Pres., C. G. Jones; Treas., S. A. Steward, both of Oklahoma City, Okla.

TERMINAL R. R. CO. OF ST. CHARLES.—Incorporated in Missouri to build a system of tracks to connect the St. Charles Car Works with the Missouri, Kansas & Texas and the Wabash railways; capital stock, $40,000; H. B. Dencles, J. G. Lawler, C. W. Prosser, B. F. Becker, John Pfeiffer.

Rocky Mt. and Pacific—Existing Roads.

SANTA FE, PRESCOTT & PHOENIX.—A press dispatch from Phoenix, Ariz., states as follows: A plan has been inaugurated by several business men, in concert with ex-Gov. Murphy, of the Santa Fe, Prescott & Phoenix R. R., to facilitate the construction of the road, and at the same time furnish employment for a large number of laboring men of this vicinity. The plan contemplated is a popular subscription to a fund for grading 70 miles out of Phoenix, at a cost of not less than $500 per mile, the subscribers to be reimbursed by first mortgage bonds of the company at par. Subscriptions have already been opened and the plan is enthusiastically received. Under the terms work is to begin Jan. 20 at this end of the line. About 300 men are now employed on the northern end.

Projects and Surveys.

NICOLA VALLEY.—Bids will be received until Jan. 10 for the construction of this railway from Spence's Bridge to Nicola Lake, B. C. Secy., J. W. McFarland, 161 Cordova St., Vancouver, B. C.

SAN DIEGO, FORT YUMA & ATLANTIC.—Incorporated in California to build a railway from San Diego to near Fort Yuma and thence to connect with a railway to be built to Phoenix, Ariz.; capital stock, $7,000,000. Dwight Breman, Boston, Pres. San Diego Land & Town Co., is the chief stockholder, and this is probably the proposed extension of the National City & Otay R. R., noted in our issue of Dec. 14, as this company is subsidiary to the land and town company.

SAN FRANCISCO & ATLANTIC.—Mention has been made recently of the reports that this railway would be placed under construction at an early date. It is now stated that bids are being received for the construction of the San Francisco & West Shore R. R., which is part of this project. The reported scheme is that the new road will intersect the Atlantic & Pacific line at some place in Los Angeles or Kings county. It is also said that contracts have been awarded for the construction of 300 miles of road south from San Francisco.

WYOMING.—A press report states that a railway 32 miles in length will be built from Laramie, Wyo., on the Union Pacific, to the Lookout Mountain coal mines.

Foreign.

MEXICAN NATIONAL.—Reports from Matamoros, Mex., state as follows: The Mexican National R. R. Co., which owns the Matamoros & Monterey R. R., running between this city and San Miguel, along the valley of the Rio Grande River, has given orders for the immediate extension of the line to the town of Camargo, in the direction of Nueva Laredo, where connection will eventually be made with the main line

STREET AND ELECTRIC RAILWAYS.

LEWISTON, ME.—It is stated at this place that Frank Jones and Arthur Sewall, late president Main Central R. R., are interested in a proposed electric railway to be built between Portland and Boston.

HANOVER, MASS.—The plan of building a new electric railway from Assinippi through North Hanover to Rockland is being agitated by leading citizens. It is proposed to form a company to build a road to the Hanover line, where it will connect with the Rockland & Abington St. Ry., which has promised to lay its tracks through Webster St. in Rockland, according to reports. It will cost about $12,000 to build the road and about $5,000 of this sum has already been raised.

MARLBORO, MASS.—A franchise has been granted to the State Central St. Ry. Co., the construction of the road to be commenced by Sept. 1, 1894, and the work completed by Oct. 1, 1895.

HARTFORD, CONN.—It is reported that a contract for building the electric railway from this city to New Britain and Unionville has been awarded and that the work will be finished by April, 1894. The new road will be called the Hartford & West Hartford Electric road. The Hartford Light & Power Co. will furnish the electricity.

NEW HAVEN, CONN.—Work will be commenced this week, according to reports, upon an extension of the Morris Cove Electric Ry. to Lighthouse Point.

BROCTON, N. Y.—It is rumored that O. W. Powell will build a street railway from the business portion of this place to the railway station, a distance of one mile, the road to be in operation by July 1.

BROOKLYN, N. Y.—The highway commissioners of the town of Flatbush have granted a franchise to the Brooklyn City R. R. Co. for an electric railway through Nostrand Ave. The road will be about three miles long and will probably be extended to Sheepshead Bay at some future time. The road is to be in operation July 4, 1894.——There is talk of building an electric railway from Huntington by way of Cold Spring Harbor to Oyster Bay. The distance is about eight miles.

PASSAIC, N. J.—The council has passed to a third reading the ordinance granting a franchise to the Passaic, Rutherford & Carlstadt Electric Ry. Co.

POTTSTOWN, PA.—It is stated that the contract for the construction of the Pottstown, Boyertown & Reading Ry. between this place and Boyertown, seven miles, has been awarded to Chas. R. Eberly, Philadelphia, at about $100,000. The material will be secured this winter and the road be built early in the spring. Pres., J. B. Craighead, Philadelphia; Secy., M. G. Tagor, Pottstown.

HAGERSTOWN, MD.—J. A. Vandergrift, Ch. Engr. and contractor of the South Mountain Electric Ry., is reported as stating that he has completed the survey of the proposed extension from Boonsboro'. The line will be 12 miles long and will run through Beaver Creek, Mapleville, Smoketown, Jugtown, Pondsville, Cavetown, and come out at Smithsburg, where a connection will be made with the Western Maryland Ry. A branch will probably be built to Black Rock. The maximum grade is 3% and the extension will cost about $125,000.

CHARLOTTESVILLE, VA.—The council is considering an application for a franchise for an electric railway.

PARKERSBURG, W. VA.—The Park City Ry. franchise has been sold to the American Const. Co., of Boston, for $50,000, according to reports. The construction of the line will be begun in a few days.

DAYTON, O.—The stockholders of the City Ry. Co. are voting on a proposition to issue $690,000 of 6% preferred stock to equip its lines for using electricity as a motive power.

NORWALK, O.—A dispatch to the Cleveland "Leader" states that the electric railway to Fairchild and Greenfield will be built next year.

TIFFIN, O.—The Tiffin & Inter-Urban Ry Co. has been incorporated by Thos. B. Williams, C. F. Shaw, F. W. Brightman, N. W. Miller, Meshech Frost, Amandus Betts, R. W. Brown and T. T. Rosenthale, to build and operate a street railway through this city, Fostoria, Upper Sandusky, Fremont and Norwalk; capital stock, $300,000.

KANSAS CITY, MO.—The Merriam Park, Rosedale & Kansas City Electric Ry. Co. has been organized to build an electric railway from Merriam to Rosedale, connecting at the latter point with the line of the Metropolitan St. Ry. Co.; capital stock, $50,000; A. A. Pearson, E. G. Bartberger, Dr. J. C. F. Maloney, B. F. Hollenback, T. J. Wilson, John R. Foster, George Branham, D. R. Mattney, C. W. Brown.

SPOKANE, WASH.—Bob Goran has made surveys for an important electric railway in the Lake Chelan district, if newspaper reports can be relied upon. The company to build the road is said to have been organized some time ago, but since the Great Northern men made their favorable report of the Okanogan country the project has taken new life and it is now proposed to construct at an early date an electric railway from Chelan Falls to Lakeside, where connection would be made with a line of steamers to the mouth of the Stehekin River; thence the road would be built up the river about 25 miles through rich mining country, with branches up several creeks.

ELEVATED RAILWAYS.

BROOKLYN, N. Y.—The Kings County Elevated R. R. Co. has contracted with the Phoenix Bridge Co. for an extension of its structure from Montauk Ave. to the city line, a distance of about a mile, and the construction will be commenced at once.

CHICAGO, ILL.—A majority of the council committee on streets and alleys north has agreed to recommend to the council for passage the ordinance of the Northwestern Elevated R. R. Co., the last of the four ordinances for elevated railways in the North Division to be introduced into the council. The incorporation of this company was noted last month.——It is stated that the Lake St. Elevated R. R. Co. will issue bonds for $10.000.000 and construct the proposed North Side branches at as early a date as possible.

KANSAS CITY, MO.—It is expected that work will be commenced about March 1 on an extension of the Kansas City Elevated Ry. from Eighth and Wyandotte Sts. to Thirteenth and Walnut Sts.

HIGHWAYS.

NEW JERSEY.—Surveys are being made of the highway between New Brunswick and Bonhamtown, a distance of five miles, and it is stated that bids will soon be asked for macadamizing the road.

MARYLAND.—A new road is proposed from Union Chapel road to Carr's Mill, in Ellicott.

ALABAMA.—Colbert county has sold $100,000 of bonds at par, the proceeds to be used in building turnpike roads in the county.

OHIO.—Bids are asked until Jan. 10 for improving State Hill, in Sharon township, the work including 251 perches of stone masonry, 116 perches limestone backing, 550 cu. yds. excavation, 50 cu. yds. rock excavation and 30,000 cu. yds. fill. Henry J. Caren, Co. Aud., Columbus.

WASHINGTON.—It is proposed to build a good road from Snohomish to Lake Stevens, the expense to be borne equally by the county, the city and property owners.

BRIDGES AND TUNNELS.

BOSTON, MASS.—The aldermen have voted to order the construction of a subway under Tremont St., at an estimated cost of $2,000,000. This work was authorized by the last legislature and will consist of a trench 14 or 15 ft. deep and wide enough for four parallel street railway tracks, according to press reports, and covered over with a roof upon which the pavement will be laid. It is intended to have the subway light, well ventilated and architecturally attractive, and it is expected that the facilities for rapid transit afforded by this will be so popular that eventually it will be built under Washington St. and perhaps in other streets.

ROCHESTER, N. Y.—It is hoped to commence work in January upon a lift bridge to be built across the canal at Emerson St., at an estimated cost of $15,000.

MOBILE, ALA.—It is reported that the county commissioners will soon ask for bids for the construction of a bridge over Three-Mile Creek, to cost about $8,000. T. W. Nicol, Engr.

CHATTANOOGA, TENN.—Press reports state that the Chattanooga Co., Ltd., broke ground Dec. 20 for the construction of a bridge over the Tennessee River at that place, at an estimated cost of $750,000.

KNOXVILLE, TENN.—Plans are being prepared for an iron viaduct in West Knoxville.

CLEVELAND, O.—Bids are asked until Jan. 17 for rebuilding the Petrie St. bridge with a steel and iron superstructure, with the necessary foundations and abutments; also for an earth embankment in place of a steel and iron structure. J. H. Farley, Dir. Pub. Wks.

COLUMBUS, O.—Plans have been prepared for the proposed Front St. viaduct, the work contemplating a two-span, through, pin-connected truss bridge, with three trusses to each span; estimated cost, $139,076.

SIOUX CITY, IA.—A resolution has been presented in council providing for the construction of a bridge over Bacon Creek on Grand St.

WATER-WORKS.

PETERBORO, N. H.—Surveys have been made by E. W. Jones for a supply from Cunningham Pond and the question of works will be considered at the town meeting in March.

BOSTON, MASS.—The city engineer has reported that a system of 12-in. pipe for supplying salt water for fire protection could be laid in certain streets at a cost of $50,000.

MEDFORD, MASS.—Ground has been broken for an auxiliary pumping station on Forest St. Engr., M. M. Tidd, Boston.

NEWTON, MASS.—The board has been authorized to spend $25,000 for pipe and castings.

SALEM, MASS.—The report on an additional supply recommends that 275 acres of land be taken on Longham meadow and the adjacent watershed, at a cost of $27,000, and that a dam be built at an estimated cost of $40,000.

JOHNSTOWN, N. Y.—Wm. S. Franklin is said to have made surveys for a supply seven miles distant, where it is proposed to construct a dam 950 ft. long and 80 ft. high.

NEW YORK, N. Y.—The aqueduct commissioners have approved the map submitted for the proposed reservoir at Jerome Park and the commissioner of public works has been requested to transmit a final plan sheet showing lands required, together with plans and specifications for the construction.

WELLSBURG, N. Y.—The citizens have voted to appropriate $5,000 for works. A reservoir is proposed, with a supply from springs.

BLOOMFIELD, N. J.—The contract with the Orange Water Co. expires Jan. 1, 1894, and efforts are being made to secure municipal works.

CANNONSBURG, PA.—A 5,000-barrel cistern on the hill north of the town, with a supply pumped from the creek, is proposed for fire protection.

JUNIATA, PA.—A committee has been appointed by the council to consider the question. A private company is being organized.

LIGONIER, PA.—Steps are being taken to secure plans for works, recently noted as voted.

NORRISTOWN, PA.—Work will be commenced within a few days, according to reports, upon a 3,500,000-gallon reservoir. The supply will be from six wells, now being sunk.

HYATTSVILLE, MD.—Wm. M. Lewin, Clk., writes us that no steps have yet been taken to secure works. Press reports state that it is not unlikely that the legislature will be petitioned for authority to issue $25,000 of bonds for works and sewers and that the citizens propose to employ an engineer to submit plans for these improvements.

WINCHESTER, VA.—An election will be held Jan. 16 to vote on an issue of $30,000 in bonds for an additional supply.

AIKEN, S. C.—An artesian supply has been secured, and it is reported that works will be put in at once.

MACON, GA.—The mayor states that the ability of the city to buy or build works is the only question now before the citizens.

SUMMERVILLE, GA.—We are informed that the village has had its charter amended so that bonds may be issued, but that it will probably be a year before definite steps are taken for works.

KEY WEST, FLA.—The board has decided to employ an engineer to prepare plans for the proposed works. Several propositions have been considered during the past year.

QUINCY, FLA.—The citizens have voted to issue $20,000 in bonds for works.

SCRANTON, MISS.—An artesian supply has been secured and works will be put in, according to reports.

HOPKINSVILLE, KY.—The Hopkinsville Water, Light & Power Co. contemplates putting in works in connection with its electric light plant, and will want pipe, pumps, etc.; population, 7,500.

SHELBYVILLE, KY.—A committee has been appointed to secure an engineer to make plans. S. Reed, Tn. Clk.

BOND HILL, O.—The council is considering the question of building works.

COLUMBUS, O.—Bids are asked until Jan. 3 for two 12,000,000-gallon duplex, compound condensing crank and flywheel, horizontal engines; also for eight steel boilers. F. M. Senter, Clk., Bd. Pub. Wks.

SPRINGFIELD, O.—It is proposed to issue $100,000 of bonds for improvements.

ST. BERNARD (P. O., LUDLOW GROVE), O.—Henry Narre writes us that Geo. Hornung, Cincinnati, has been engaged to prepare plans for proposed works. The works will have duplicate pumping machinery, each pump of 1,000,000 gallons capacity, 10 miles of pipe, a water tower and about 80 fire hydrants. The election to vote on the construction will not take place until the latter part of February.

HAUGHVILLE, IND.—The Indianapolis Water Co. has offered to lay a main in Michigan St. and to put in 13 fire hydrants.

MARSHALL, MICH.—An election will be held Jan. 15 to vote on an issue of bonds for $50,000 for works. The present works may be purchased.

CHICAGO HEIGHTS, ILL.—It is reported that negotiations are being made for works.

EMDEN, ILL.—Residents of the village are reported as proposing to sink a well, purchase a windmill and elevated tank and lay pipes in the principal streets.

PANA, ILL.—Plans and specifications are about ready and it is expected that the construction will be commenced as soon as possible.

CENTRALIA, WIS.—The citizens have voted to issue bonds to put in works.

BOONE, IA.—About 26,000 ft. of 6-in. main will probably be laid and a meter put on every tap.

GRISWOLD, IA.—D. H. Scott, Cy. Clk., writes us that plans will be submitted Jan. 1 and bids will then be asked for constructing works, which include a stand-pipe; population, 1,100.

INDIANOLA, IA.—The question of works is being agitated, according to reports.

OTO, IA.—The proposed works, recently noted, are said to be for fire protection.

PARKERSBURG, IA.—M. F. Edwards, Cy. Recorder, informs us that bids will probably be received in about 20 days for works to cost about $6,000, including tank, pump, 8, 6 and 4-in. mains; population, 1,000.

DULUTH, MINN.—Bids are asked until Jan. 8 for $800,000 of water and light bonds.

MORTON, MINN.—It is reported that a proposition to issue bonds for $10,000 for works will soon be voted upon and that if the vote is favorable the construction of works will soon be commenced.

SARATOGA, WYO.—It is proposed to construct works, according to reports.

BOLIVAR, MO.—Bids are asked until Feb. 1 for the construction of works, as stated in our advertising columns. C. H. Skinker, Cy. Clk.

LAMAR, MO.—The city has contracted with the water company for 65 hydrants for one year, at $1,500, it is said.

POPLAR BLUFF, MO.—The citizens have voted to issue bonds for $20,000 for the construction of works.

BROWNSVILLE, TEX.—We are informed that a private company will probably put in works next year, the supply to be pumped from the Rio Grande River to reservoir; estimated cost, $40,000; population, 8,000; Engr., Wm. P. Rounds.

HOUSTON, TEX.—The council has accepted a report of the board of public works recommending the appointment of an engineer to report upon the feasibility and estimated cost of municipal works.

DENVER, COLO.—Rumors of a possible consolidation of the American and Citizens' water companies have caused renewed agitation in favor of works to be owned by the city.

EVERETT, WASH.—The council has voted to submit to the citizens a proposition to issue bonds for the purchase of the works.

HOQUIAM, WASH.—O. P. Burrows, Cy. Engr., writes us that bids are being asked for $24.000 of 6% bonds, and also for the construction of works, the bidder to accept bonds in payment. Proposed work includes a 1,500,000-gallon pumping engine, reservoir, and 2½ miles of 6 and 4-in. pipe.

NEW WHATCOM, WASH.—Over 400 men were at work last week extending the mains to Keeslingsville. The city has $23,000 of water funds on hand at present and $75,000 of bonds for improvements remain unsold.

SPOKANE, WASH.—Press reports state that the temporary injunction against the awarding of section A to H. L. Cooper, at $229,459, as noted Dec. 14, has been made permanent and that it is proposed to do the work by day labor.

TACOMA, WASH.—The superintendent has been directed to filter the supply taken from Clover Creek.

TILLAMOOK, ORE.—The citizens are discussing an issue of bonds for putting in works.

OAKLAND, CAL.—The Oakland Water Co. has been incorporated by W. J. Dingee, A. Hayward, A. W. Rose, Jr., W. E. Sell and H. G. Stevens; capital stock, $3,000,000; principal office, San Francisco.

WINDSOR, ONT.—C. J. Reid, Secy. W.-W., writes us that the commissioners have been restrained by injunction from proceeding with the proposed work, the bids have been returned unopened and the matter is closed for the present.

ARTESIAN WELLS.

GRAND VIEW, S. DAK.—Bids are asked until Dec. 30 for sinking and casing four 6-in. artesian wells. M. N. Stultz, Co. Aud.

IRRIGATION.

SPOKANE, WASH.—The "Chronicle" states that it is expected that the construction of a large irrigation ditch in the Okanogan Valley will be commenced this next year. The valley is about 100 miles long and it is thought that a canal carrying 25,000 ins of water would cost $500,000.

PALM SPRINGS, CAL.—Henry L. Ryan has been making surveys for an irrigation ditch to be about two miles long, upon the government Indian reservation at this place.

MATAMOROS, MEX.—A press report from this city states that surveys have been commenced for an irrigation ditch from Camargo, down the river 100 miles, and that the enterprise will be pushed as rapidly as possible.——We have also received the following letter, which probably refers to the same project: Operations have been begun by Srs. Nunez, Vivanco and other capitalists of the City of Mexico to build dams in Rio Grande River 30 miles above Laredo, Tex., and on the San Juan River, and to irrigate the cotton lands lying on the south side of the Rio Grande River between Guerro and Reinosa, Mexico. About 50 miles of ditch 14 meters wide is contemplated and surveys have been commenced. The chief engineer is Scougal for the Mexican government. It is expected that the work will cost $1,000,000.

NEW COMPANIES.—Midland Irrigating Land Co., Omaha, Neb.; $1,250,000; Isaac Coe, Levi Carter, John Brant, Nathan Shelton, Frank Murphy, J. E. Mark l, Alvin Saunders.——Elk Fork & Dry Creek Land & Irrigation Co., Helena, Mont.; $50,000; operations to be carried on in the Sun River Valley, with an office at Augusta.

SEWERS.

BOSTON, MASS.—The council has appropriated $500,000 for sewers and streets. There is an unexpended sum of $150,000 raised by a previous loan for the same purpose.

HUDSON, MASS.—A system is being agitated, and it is reported probable that a meeting will be held to discuss the subject.

TAUNTON, MASS.—It is reported that the city engineer will prepare plans for sewers in Ward 1.

WALTHAM, MASS.—The sewer board has recommended that sewers be laid in Howard Ave. and Gorman's Court.

WATERBURY, CONN.—The city engineer has been instructed to report on plans for the disposal of the city's sewage other than by discharging it into the Naugatuck River. About a year ago the committee recommended that the necessary legislation be obtained for building a trunk sewer from this city to Long Island Sound.

LONG ISLAND CITY, N. Y.—The contract for a sewer in Harris Ave. has been awarded to J. C. Sheehan, of New York, at $92,764. The only other bid was that of Geo. H. Smith, Steinway, at $125,807.

WHITESTONE, N. Y.—The village clerk has been directed to advertise for bids for several branch sewers.

JERSEY CITY, N. J.—The board of finance has authorized the construction of a main sewer to drain the western slope of the hill. It is to be siphoned under Morris Canal and empty into Newark Bay; estimated cost, $90,000

LAMBERTVILLE, N. J.—C. P. Bassett, Orange, has prepared plans which will be considered by the council at the January meeting; total length, 27,280 ft.; estimated cost, $28,674.

ALTOONA, PA.—The lowest bid for the second district sewer was that of Reilley & Riddle, Philadelphia, at $32,998.

MACON, GA.—C. W. Hendrick, Cy. Engr., informs us that the city hopes to begin work on the proposed system, noted last week, about the first of the year.

LEXINGTON, KY.—S. C. Campbell, Chn. Com., informs us the city is negotiating with engineers for plans for a system.

CINCINNATI, O.—The contract for the Badgely Run sewer has been awarded to B. D. Barton, at $113,393; estimate, $153,075.

HAMILTON, O.—Several engineers have addressed the members of the Merchants and Manufactures Club concerning a system for the city.

SANDUSKY, O.—The engineer has estimated that a proposed sewer in Madison St. would cost $10,493.

MILWAUKEE, WIS.—Bids will be asked for 6 and 10-ft. sewers at Bay View, according to reports.

AURORA, ILL.—It is reported that the bids for a sewer in Hazel Ave. and Sims St. may be rejected and the work readvertised. The total bids were published in our issue of Dec. 14.

BOONE, IA.—Plans have been prepared for about 25 miles of 6 to 18-in. sewers, and bids will soon be asked for constructing a part of the system.

SIOUX CITY, IA.—T. H. Johnson, Cy. Engr., informs us that the difficulties that prevented the awarding of contracts for proposed sewer work last fall have been overcome, and that it is hoped that the contracts will soon be awarded, in accordance with the call for bids published in our advertising columns.

GREELEY, COLO.—The sewage is to be utilized upon 210 acres of land below the city, according to reports.

STREETS.

BOSTON, MASS.—The aldermen have ordered the city treasurer to sell $250,000 of 20-year bonds for work in Commonwealth Ave.

MILFORD, MASS.—A special town meeting is to be called to consider an appropriation of $10,000 for repairing highways and laying out new streets, according to reports.

NORTHAMPTON, MASS.—The superintendent of streets has recommended that bonds be issued for $100,000 for macadamizing streets.

SPRINGFIELD, MASS.—The council is considering an appropriation of $20,000 for improving streets.

NEW YORK, N. Y.—The park commissioners have advertised for bids for constructing that section of the Harlem River speedway from 150th St. to High Bridge, the bids to be opened on Jan. 18. The estimated cost is $1,000,000, and the section is to be finished in 375 working days. The plans call for a single sidewalk on the land side.

TONAWANDA, N. Y.—It is reported that considerable paving will be done next season.

CINCINNATI, O.—The board of administration will receive bids until Jan. 12 for paving three streets with brick.——M. T. Flynn has been awarded the contract for paving in Glen Parker Ave. with brick, at $6,867; estimate, $9,619.——An appropriation of $25,000 is proposed for macadamizing streets in the suburbs.——The board of administration has authorized the sale of $300,000 of 4% paving bonds for work to be done in 1894.

BELDING, MICH.—An election was held Dec. 26 to vote on an issue of bonds for $10,000 for public improvements.

WACO, TEX.—A report of the street committee recommending that six miles of streets be graded and paved has been approved by the council.——The council has adopted a resolution looking to an issue of $30,000 in bonds for additional street work.

ELECTRIC LIGHT AND POWER.

PHILADELPHIA, PA.—Bids for lighting the city ranged from 38 to 55 cts. per night for each 2,000-c. p. arc light, the prices depending in part upon the district to be lighted.

RIPLEY, TENN.—A contract for street lighting has been awarded to W. F. Carloss and others, at $1,500 a year. A company is being organized and a plant will be put in as soon as possible.

MARTIN'S FERRY, O.—The council has voted to award a contract for lighting the city with 2,000-c. p. arc lights, the city to have the right to purchase the plant after one year.

ST. BERNARD (P. O., LUDLOW GROVE), O.—Geo. Hornung, Cincinnati, has been engaged to prepare plans for proposed water-works and an electric light plant for 80 arc and 1,000 incandescent lights.

INDIANAPOLIS, IND.—The county commissioners will receive bids until Jan. 15 for an electric light plant for the court house and jail; estimated cost, $10 000 to $12,000.

MOLINE, ILL.—It is reported that the city will spend $300,000 on its plant.

HAMPTON, IA.—The council is considering the advisability of enlarging the electric light plant in order to provide more commercial lights.

NEW ULM, MINN.—The Electric Light Co. is reported as contemplating the purchase of an arc light plant.

GEORGETOWN, TEX.—We are informed that a contract will be awarded the first of the year for an electric light plant to cost about $15,000.

PORT ANGELES, WASH.—The contract for constructing electric plant to generate about 500 HP. has been awarded to W. C. Williams, at $37,000, according to reports.

NEW COMPANIES.—Mechanics' General Mfg. Co., St. Paul, Minn.; $10,000,000; D. H. Kent, St. Paul Park; A. A. Price, F. M. Johnson, P. L. Uttley, C. J. Backus, St Paul.——Milwaukee Arc Light Co., Milwaukee, Wis.; $100,000; Gottlob Weninger, Henry A. Adler, B. Conrad.——Stephenson Electric Light Co., Stromsburg, Neb.; $25,000; J. B. and P. T. Buckley, J. A. Frawley, G. S. Osborne, Dr. W. A. Post.——Madera Electric Co., Madera, Cal.; $100,000; F. W. Krogh, C. A. Krogh, G. G. Buckland, H. K. Olsen, Sol Lazler.——Wallace Electric Co., Chicago, Ill.; $2,000; W. J. Candlish, Killian V. R. Lansing, Jessie F. Pebbles.

CONTRACT PRICES.

SEWERS.—Providence, R. I.—The following lowest bids were received Dec. 2 for circular brick sewers: Section 10, 102-in., 2,322 lin. ft., average cut 26 ft., Frederick E. Shaw, Providence, $58,249, time 110 days; Sec. 11, 102-in., 2,248 lin. ft., average cut 23 ft., G. R. Newman, Providence, $64,331, time 130 days; and Sec. 12, 102-in., 2,322 lin. ft., average cut 22 ft., $60,587, time 160 days; Sec. 13, 74-in., 1,458 lin. ft., average cut 22 ft., J. J. Newman, Providence, $39,252, time 90 days; Sec. 14, 74-in., 1,665 lin. ft., average cut 20 ft., F. E. Shaw, $46,437, time 85 days. The prices of the lowest bids were as follows:

	Sections.				
Work.	10	11.	12.	13.	14.
Trench excav., per lin. ft.	$15.00	$17.50	$17.75	$19.00	$19.00
Excav. not in trench, per cu. yd.	1.00	1.70	1.70	2.00	3.00
Brick mas., Am. cem., per cu. yd.	6.00	4.75	4.70	4.75	6.00
Brick mas., Port. cem., per cu. yd.	7.00	4.75	4.75	4.75	7.00
Concrete, Am. cem., per cu. yd.	5.00	4.75	4.70	4.75	5.00
Dim. stone masonry, per cu. yd.	4.00	3.00	3.00	1.00	4.00
Drain pipe, per lin. ft.	0.05	0.05	0.05	0.10	0.01
Piles, per lin. ft.	0.20	0.15	0.15	0.05	0.20
Spruce lumber, per M ft. B. M.	25.00	35.00	35.00	35.00	25.00
15 and 12-in. bevel connections, at	0.50	0.25	0.20	0.50	0.50
8 and 6-in bev. con'ct's, at	0.50	0.02	0.02	0.20	0.50
Grav. backfill'g, p'r cu. yd.	3.00	1.75	1.70	1.25	3.00

The other bidders were as follows: Metropolitan Const. Co., Boston; Geo. S. Good & Co., Rock Haven, Pa.; F. A. Snow, Providence; Everson & Liddle, Providence; Moulton & O'Mahoney, Lawrence, Mass.; Mansfield & Olmsted, Allston, Mass.; Timothy F. Lyons, Providence; National Const. Co., Boston; Andrew W. Byrne, Somerville, Mass. The contract for each section was awarded to the lowest bidder, though those for sections 11, 12 and 13 were transferred to Everson & Liddle.

Richmond, Ind.—The following bids have been received for two 12-in. pipe sewers, the price being given per lin. ft. and including branches, manholes, etc.: Fries, Barr & Co., Greenfield, $1.57 and $1.77; F. W. Rehling, Richmond, $1.22 and $1.73; Tim Cronin, Richmond, 98 cts. and $1.20; John O'Neal, Richmond, $1.09 and $1.58; W. J. Irwin, Greenville, $1.45 and $1.55.

SEWER PIPE.—Brockton, Mass.—The following bids for the manufacture and delivery of 12,000 ft. 5-in. sewer pipe, 3,000 ft. 6-in., 11,500 ft. 8-in., 7,500 ft. 10-in. and 1,000 ft. 12-in. vitrified, salt-glazed sewer pipe were received by F. Herbert Snow, Cy. Engr., Dec. 18, the bids being a discount on the eastern price list of Jan. 20, 1887: Otis & Grosline, New York, 60%; D. W. Lewis, Boston, 68%; W. G. Nash, Boston, 72%; Potomac Terra Cotta Co., Washington, D. C., 73%; Portland Stoneware Co., Boston, standard pipe 73%, deep socket 60%, double strength 50%; H. Wales Lines Co., Meriden, Conn., 74½%, exclusive of inspector; Waldo Bros., Boston, 73½%.

PUMPING ENGINE.—Boston, Mass.—The following bids for a vertical, compound, beam and flywheel engine, having a capacity of 10,500,000 gallons, were received by the Boston water board on Dec. 23: Groshon High Duty Pumping Engine Co., New York, $38,000; Geo. F. Blake Mfg. Co., Boston,, $38,950; Builders Iron Foundry, Providence, $44,444; The I. P. Morris Co., Philadelphia, $54,750; William Sellers & Co., Philadelphia, $75,000.

PIPE.—Cincinnati, O.—The park commissioners have awarded a contract for 1,992 ft. 6-in. pipe and 9,180 ft. 4-in. pipe to the Radford Pipe & Foundry Co., Radford, Va., at $19.95 per ton of 2,000 lbs.

Bangor, Me.—The water board has received a bid to furnish 6,000 ft. 20-in. pipe, at $24.60 per ton of 2,240 lbs. f. o. b. in this city, according to press reports.

GAS LIGHTING.—New York.—Bids have been opened for furnishing gas for lighting public buildings during 1894. The law forbids a charge of over $1.25 for 1,000 cu. ft. of gas and all bids received were at that price, the bids being for 20, 25 and 30-c. p. lights. The total cost will be about $54,000.

DRAINAGE CANAL.—Chicago, Ill.—The following contracts were awarded by the drainage board on Dec. 23: Gahan & Byrne, sections G and H, at 28 and 29 cts. per cu. yd., respectively; Christie & Lowe, I and K, at 25 cts.; Heidenreich Co., L and M, at 19.7 and 21.7 cts. The bids for this work were published last week.

MISCELLANEOUS CONTRACTS AND SUPPLIES.

PARK BONDS.—Muskegon, Mich.—The city has sold $100,000 of 5% 30-year bonds for park purposes.

WATER TOWER.—Columbus, O.—Bids are asked until Jan. 2 for a water tower not less than 65 ft. high. F. M. Senter, Clk., Bd. Pub. Wks.

STEAM ROLLER.—Lawrence, Mass.—The superintendent of streets has recommended the purchase of a 15-ton steam roller, at an estimated cost of about $4,000.

STREET CLEANING..—Nashville, Tenn.—Bids are asked until Jan. 2 for street cleaning and scavenger service in districts 1, 2, 3, 4 and 5, for one year. J. A. Jowett, Cy. Engr.

BULKHEADS.—Philadelphia, Pa.—The trustees of the Girard Estate are considering an expenditure of $500,000 for the construction of bulkheads on the Delaware River, according to reports.

DAM.—Providence, R. I.—The "Journal" states that the Pawtuxet Valley manufacturers are having surveys made about three-quarters of a mile above the Barden reservoir, in Foster, for the building of a reservoir. The scheme calls for the building of a dam about 1,000 ft. in length, and it is estimated that the reservoir will have a capacity of about 1,000,000,000 gallons.

DITCH.—Wabash, Ind.—The Indianapolis "News" states that all preliminaries for the construction of the big ditch on the Kosciusko county line have been arranged, and the work will be commenced in spring. This ditch will be the largest in Northern Indiana. It will be 20 miles long, 50 ft. wide, an average of 10 ft. deep, and will drain 20,000 acres of land. The cost will be $40,000, and 800 property owners are assessed for its construction.

INDUSTRIAL NOTES.

THE WICKES REFRIGERATING & CAR CO. has recently opened offices on the ground floor of the Monadnock Block, Chicago. This company reports a large and increasing business in refrigerator and cold storage work. On Jan. 1, 1894, it will have in operation 250 new Wickes refrigerator cars, which it is proposed to lease to shippers, railways and transportation companies. The new Wickes car was described in our issue of Nov. 16, 1893.

THE HARVEY STEEL CAR & REPAIR WORKS, Harvey, Ill., has the contract for repairing 200 Eastman heater cars for the Central Car Trust, and 100 refrigerator cars belonging to the Western Rolling Stock & Equipment Co., for N. K. Fairbanks & Co., Chicago; also for doing repairs at Chicago for the Northern Pacific R. R. and the Chicago & Calumet Terminal Ry.

THE PULLMAN PALACE CAR CO., of Chicago, Ill., has an order for 55 cars for the Long Island R. R. They are to be fitted with Westinghouse brakes and the Miller platform and coupler.

THE NEW YORK MASTIC WORKS have been awarded the contracts for Seyssel asphalt work in additions to the American Bank Note Co.; boiler house, Fine Art Museum, New York; Soldiers' Home, Norotno, Conn., and the Havemeyer scneel, Greenwich, Conn.

THE HERCULES ICE MACHINE CO. has acquired the plant of the Hercules Iron Works at Aurora, Ill., and has contracts for ice and refrigerating machinery to the amount of $100,000.

RAILS.—The Colorado Fuel & Iron Co., of Pueblo, Col., has a contract for 30,000 tons of steel rails for the Union Pacific.

THE WESTINGHOUSE ELECTRIC & MFG. CO., of Pittsburg, Pa., has a contract for six 1,500-HP. generators and two 750-HP. generators for the Philadelphia Traction Co.'s power station.

NEW COMPANIES.—Lowell Dredging Co., Lowell, Ind.; $5,100; Pres., George W. Lawrence; Gen. Man., John Hack; Secy., E. W. Dinwiddie. Chesapeake & Ohio Transportation Co., Hagerstown, Md.; $250,000; J. C. Lane, of Hagerstown; C. K. Lord and H. C. Black, of Baltimore, Md. Stiles Bridge & Construction Co., Kansas City, Kan.; $5,000; V. H. Stiles and G. E. Stiles, of Kansas City, Mo. Calhoun Excavator Co., Chicago, Ill.; $3,000; C. S. Calhoun and Chas. E. Lathrop. Barnes Car Coupler Co., East St. Louis, Ill.; $1,000,000; A, Cherwood, J. P. O'Connor and C. Y. Dyce.